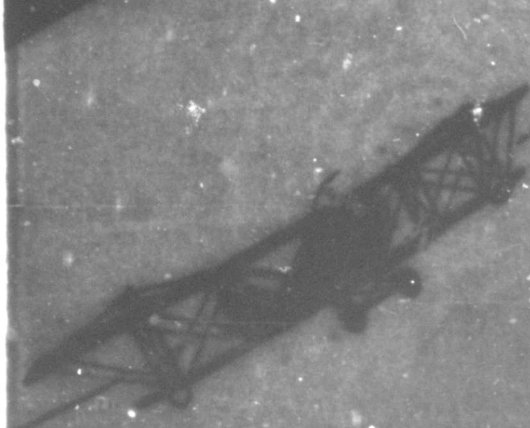
50 years OF AEROSPACE MEDICINE

1918 ★ 1968



UNITED STATES AIR FORCE
SCHOOL OF
AEROSPACE MEDICINE

FIFTY YEARS OF AEROSPACE MEDICINE

ITS EVOLUTION SINCE THE FOUNDING OF THE UNITED STATES AIR FORCE SCHOOL OF AEROSPACE MEDICINE IN JANUARY 1918

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Chapter 1

BIRTH OF AN ART

In the summer of 1917 the opposing armies of the most powerful nations in Europe were immobilized along a line reaching from the North Sea to the Alps. The first World War then was three years old. In its opening months, the troops of Germany had plunged through Belgium on the road to Paris, had been halted by French and British troops at the River Marne, and had fallen back to the River Aisne. There both sides had burrowed into an intricate system of muddy trenches, besieging one another on a stationary front.

The United States had entered the War in April. It was mobilizing its forces in haste, but they were still on the other side of the Atlantic. Meanwhile, in France, between artillery duels, the frustrated antagonists erupted intermittently from the shelter of their trenches, to advance or retreat a few fatal yards across the desolate wasteland between them.

In this corridor of unchanging violence, only one kind of military organization enjoyed the luxury of motion. Not the cavalry, which had long since vanished from the sodden landscape, nor the armored column, which had yet to acquire the freedom of swift manoeuvre, it was that most novel of combat services, the air arm. In their fragile flying machines, the aviators of both armies performed graceful acrobatics on the dome of the sky, far above the ground.

Orville Wright had flown the first airplane less than fourteen years earlier. Since then, aviation had achieved remarkable progress. From the average speed of 6.8 miles per hour attained by the Wright Brothers' primitive craft, airplanes had reached velocities beyond 126 miles per hour.[1] From a few feet above the ground at Kitty Hawk, they had risen to altitudes higher than

20,000 feet. Flights to distances as great as 600 miles had been made without landing. Flyers had remained aloft as long as 21 hours.

Yet the airplane still was little more than a powered glider. Built of light wood and fabric, it was limited in the payload it could carry by the weight and thrust of the engine that propelled it. Aviation strategists already had defined its potentiality as a long-range bomber.[2] But in fact, so far, its use had been confined almost entirely to reconnaissance behind the enemy lines and to fighter interception. In war, the airplane was only beginning to replace the Zeppelin and the observation balloon.

The development of aviation up to 1914 had been accomplished mainly by and for amateurs, who considered flying a sport. To the military aviators who had met over the front in the early years of the War—including those Americans who had flown with the French in the Lafayette Escadrille—it was an adventure with a considerable sporting element. At the first encounter between opposing pilots, they had merely waved cavalierly at one another in passing.[3] Thereafter, they had engaged in aerial duels that recalled the chivalrous code of jousts between medieval knights on horseback.

That there was a risk in flying, apart from the danger of being wounded or shot down, was well known to these pilots. The risk was an essential ingredient of the adventure. Its exact nature and its origins were not examined too closely; the pilot's creed was to accept it with a jaunty air. Although the parachute had been successfully tested in 1914 and was used by balloonists, parachutes were not yet carried in airplanes, possibly to avoid any additional weight.[4] The pilot flew whenever he was physically able to take off, ignoring minor ailments. If he survived a crash, he was expected to go back up as soon as he could, to show that he had lost none of his zest for the hazards inherent in flying.

The flight instruction given to the fledgeling pilot was sketchy in the extreme. It rarely exceed fifty hours.[5] In effect, if he was healthy and had no obvious defects of coordination, balance, or vision, it was assumed that he could fly an airplane as readily as he could manage any other vehicle.

The natural outcome of this light-hearted attitude toward flying was that the casualties were high. Analyzing their losses

after the first year of the war, the British found that, out of every 100 aviators killed or permanently disabled, only 2 had been shot down by the enemy.[6] Of the rest, 8 had crashed because of mechanical shortcomings in the airplanes they were piloting, and no less than 90 on account of human deficiencies, including lack of skill, carelessness, reckless flying, or physical unfitness. The great majority of these casualties (60 in all) were attributed to physical unfitness, resulting from functional disorders, injury, minor indispositions, or exhaustion.

The British had devised a remedy for losses caused by unfitness. They had instituted a special medical service in what was then the Royal Flying Corps, known as "Care of the Flyer." Not a research agency for the discovery of hazards peculiar to flight, it was designed simply to guard the health of the aviator and to see that he was in good shape to fly when he took to the air.[7] By concerning themselves with the flyer's fitness, the British had cut their attrition from this cause to only 20 per cent after the second year of the War, and to 12 at the close of the third year. The larger question of human failures in judgement, skill, or adaptation to the flight environment had been left for consideration at some later period of less urgency.

In the United States, until two years before the War, interest in the basic medical problems of aviation had been mild and intermittent, touching mainly on the physiological effects of reduced atmospheric pressure with increasing altitude.[8] No specialized physical examination had been prescribed for either military or civilian pilots. Anyone who had an urge to fly was free to do so, at his own risk.

For the first time in February 1912, the War Department had prepared a medical examination to evaluate military candidates for duty in aviation.[9] In general, the standards to be met were stricter than for duty on the ground, with emphasis on visual acuity, hearing, and the sense of equilibrium, which was known to be primarily a function of the inner ear. Keen vision was of course considered vital in a three-dimensional medium, while a reliable judgement of balance was needed to determine the attitude of the airplane when visual cues were absent or confusing.

This was the physical examination for flying at the outbreak of the War in Europe, when the Army Signal Corps began to

enlarge its newly established Aviation Section.[10] But the examination turned out to be so rigorous that few applicants for transfer from the ground forces were able to pass it. On the request of the Chief Signal Officer, the standards were relaxed somewhat, so that the Army could qualify more flyers.

By 1916, it was apparent that the United States might become involved in the War. The spectacular use of military aviation on the Western Front had shown that this country would need an air service comparable to those already developed by the major European powers. To create such a service, candidates from civilian life would have to be recruited in considerable numbers, and taught to fly.

The authority on aviation standards in the office of the Army Surgeon General at the time was Major Theodore Charles Lyster, a 41-year-old medical officer who had served with distinction in Panama, in the Philippines, and in the American occupation of Veracruz, Mexico, several years before.[11] An ophthalmologist by training, Lyster had given a good deal of thought to the medical examination then in use for the Signal Corps. His opinion was that it ought to be revised completely, basing the standards on definitive studies of the physical and temperamental characteristics needed to manage an airplane in flight.

Lyster had discussed the visual problems with a prominent member of the medical community in Washington, Dr. William Holland Wilmer.[12] Then in his early fifties, Doctor Wilmer was a native of Powhatan County, Virginia, and the son and grandson of eminent Episcopal clergymen. His grandfather, for whom he was named, had been the first rector of St. John's Church in Washington, had founded the Theological Seminary in Alexandria, Virginia, and had served as President of William and Mary College.

Wilmer had taken his medical degree at the University of Virginia in 1885, had interned at Mount Sinai Hospital in New York City, and had studied ophthalmology under several noted New York specialists. For the past 27 years, he had had his own practice in Washington. Wilmer was a founder of the Episcopal Eye, Ear, and Throat Hospital and was Professor of Ophthalmology at Georgetown University. He held a commission as a lieutenant in the Medical Reserve Corps of the Army and was interested in aviation.

In 1916, at a meeting of the Academy of Medicine in Washington, Major Lyster heard a paper on the functions of the ear in flying, presented by a Philadelphia otologist, Dr. Isaac Hampshur Jones.[13] Isaac Jones was 35, a practitioner on the staff at Philadelphia General Hospital, and an instructor at the University of Pennsylvania. Like Doctor Wilmer, he was a lieutenant in the Medical Reserve Corps.

With the help of these two colleagues—one his respected senior and the other an enthusiastic junior—Lyster went ahead with his revision of the medical examination for pilots.[14] By April 6, 1917, when the Congress of the United States announced that a state of war existed with Germany, a new form and instructions were completed. A month later, as the mobilization of American strength was getting under way, they were approved and published by the War Department. The task of setting up examination centers and administering the tests was given, naturally enough, to Major Lyster.[15]

Both Doctor Wilmer and Doctor Isaac Jones had been called to active duty in the office of the Surgeon General, Wilmer as a major and Jones initially as a lieutenant. Both were assigned to Lyster, to assist him in the medical phase of the pilot recruiting program.

But Lyster now had more in mind than the examining centers. He was working out a plan for a semi-independent medical service, composed of physicians versed in the human problems of aviation, who would be attached to flying units in the field. Resembling the British "Care of the Flyer" service in its organizational aspects, it would go beyond the immediate question of the pilot's health, to explore the basic conditions that influenced the capability of men to fly. As a first requisite, he would need to assemble a group of specialists and find a way to familiarize them with the problem.

So Lyster turned over the job of organizing the pilot recruiting centers to Isaac Jones, while he kept Wilmer in Washington to assist him in the larger project.[16] For the next three months, the Philadelphia ear specialist traveled around the country, setting up examining units in 67 major cities and staffing them with 500 medical officers, trained and commissioned on the spot. Before the War ended, these examiners had processed more than

100,000 civilian applicants, qualifying almost 71 per cent of them for entry into flying schools.

Meanwhile, Lyster was making progress with his specialized medical service. On September 6, 1917, by special order of the War Department No. 207, Theodore Charles Lyster—now a lieutenant colonel—was appointed the first Chief Surgeon of the Aviation Section, Army Signal Corps.[17] This meant that he now had full authority, under the benevolent eye of the Surgeon General, to establish whatever medical organization was needed to maintain the health and efficiency of American flyers. In effect, Colonel Lyster was this country's first Air Surgeon General.

He lost no time in acting on his plan. Already he had gathered a small group of specialists in various fields associated with aviation, to form the nucleus of his medical staff.[18] All recently commissioned, they included among the doctors of medicine—besides Major Wilmer—Major Eugene R. Lewis, an otologist from Dubuque, Iowa, and Major Edward G. Seibert, a Washington internist. Also included was a doctor of philosophy, Major John Broadus Watson, Professor of Psychology at the Johns Hopkins University in Baltimore, who was celebrated as the founder of behaviorism.[19]

As a civilian advisor, the Chief Surgeon had enlisted the services of Yandell Henderson, Ph.D., Professor of Physiology at Yale University and a consultant to the Bureau of Mines.[20] Professor Henderson had performed some noteworthy research on the physiological effects of changes in altitude.

Carrying out instructions from Colonel Lyster, this group met in Washington on September 27. They discussed a variety of subjects that bore on the wellbeing of the flyer, ranging from known medical problems to physical training, from proper clothing and equipment to the design of a device to provide additional oxygen at high altitudes.[21] But their main topic was the need for an experimental research laboratory, situated at a nearby Army flying field, to investigate problems of this kind in detail.

Five days later, on October 2, they journeyed to the meadows of Long Island, stretching eastward from New York City, to consider the suitability of Hazelhurst Field, outside the town of Mineola, as a site for the laboratory. The field at Hazelhurst,

opened a year earlier, was then the Army's most important training school for flyers on the East Coast.[22] Most of the others were in the South, where year-round weather conditions were more favorable for flight instruction.

The party from the Chief Surgeon's office was impressed by Hazelhurst, particularly because of its accessibility from the major medical centers of the East in Boston, New Haven, New York City, and Philadelphia, as well as from Army Headquarters in Washington. They made one more inspection trip on October 12, to Langley Field, Virginia, across Hampton Roads from Norfolk.[23] There some of them were taken up on a flight during a severe wind storm. But they decided to build the laboratory at Hazelhurst.

On October 18, 1917, the War Department issued the authorization that Colonel Lyster had been awaiting.[24] It was contained in paragraph 113, special orders No. 243, from the Adjutant General. These orders created the Medical Research Board, responsible to the Chief Surgeon of the Aviation Section, Army Signal Corps. Appointed as members were the same four majors who had been surveying sites for a laboratory, with Professor Yandell Henderson in a civilian capacity as chairman.

The powers delegated to the Board were comprehensive. The order defined them as follows:

1. To investigate all conditions which affect the efficiency of pilots.

2. To institute and carry out, at flying schools or elsewhere, such experiments and tests as will determine the ability of pilots to fly in high altitudes.

3. To carry out experiments and tests, at flying schools or elsewhere, to provide suitable apparatus for the supply of oxygen to pilots in high altitudes.

4. To act as a standing Medical Board for the consideration of all matters relating to the physical fitness of pilots.

The practical effect of this franchise was to give the Board, under the direction of Colonel Lyster, freedom to take whatever steps it deemed necessary to establish the practice of aviation medicine (a term not yet invented) in the Army air service. Specifically, the Board was to perform exploratory and applied

research in the interest of the pilot's health and safety. By implication, it was to determine clinical standards and teach them to medical officers with flying units.

The Board promptly met and approved the actions which its members already had taken. The Medical Research Laboratory was organized formally, with a charter to begin operating as soon as its quarters were ready at Hazelhurst Field. The powers of the Board were transferred to the Laboratory, by the simple device of appointing a majority of the Board's members to the Laboratory staff.

Major William H. Wilmer became the Officer in Charge of the Laboratory.[25] He was to command it until the end of the War. His Executive Officer was Major Edward G. Seibert, who also was the Secretary of the Board.

The Laboratory was divided into six operating departments, corresponding to the medical and scientific areas then considered of most importance in aviation. Major Eugene R. Lewis was named as head of the Ear, Nose, and Throat Department.

Major John B. Watson had other interests which he wanted to pursue. (Later on, he went abroad with the American Expeditionary Forces.) His place as head of the Department of Psychology was taken by another Baltimore psychologist, Major Knight Dunlap.

Professor Henderson preferred to continue as a civilian consultant to the Laboratory. To head the Department of Physiology, the Board found a Reserve officer who also had done research on the effects of altitude, Major Edward C. Schneider (Ph. D.) from Colorado Springs, Colorado.

The rest of the staff was filled from among the newly commissioned doctors of medicine who had joined the Chief Surgeon in Washington. Major Stewart Paton, a psychiatrist from Princeton, New Jersey, was chosen to head the Department of Neurology and Psychiatry, and Major James L. Whitney, a San Francisco heart specialist, as head of the Department of Cardiology.

Captain Conrad Berens Jr., a young eye specialist from New York City, became the head of the Department of Ophthalmology.

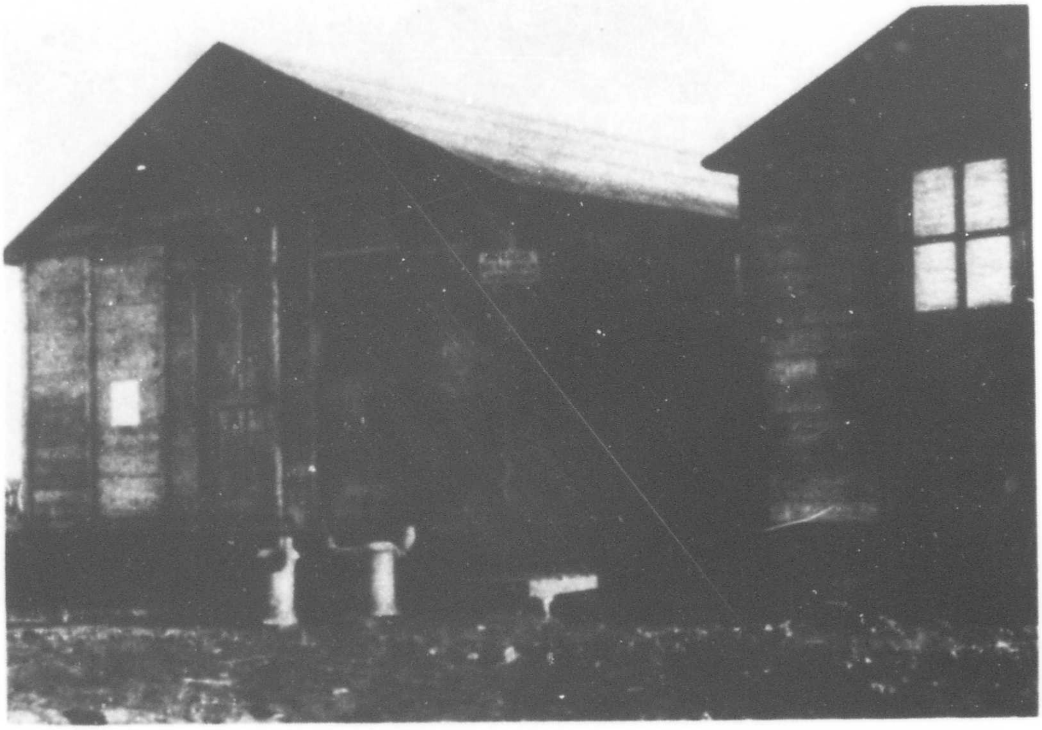

FIGURE 1 —

These two building made up the Medical Research Laboratory at Mineola, Long Island, New York.

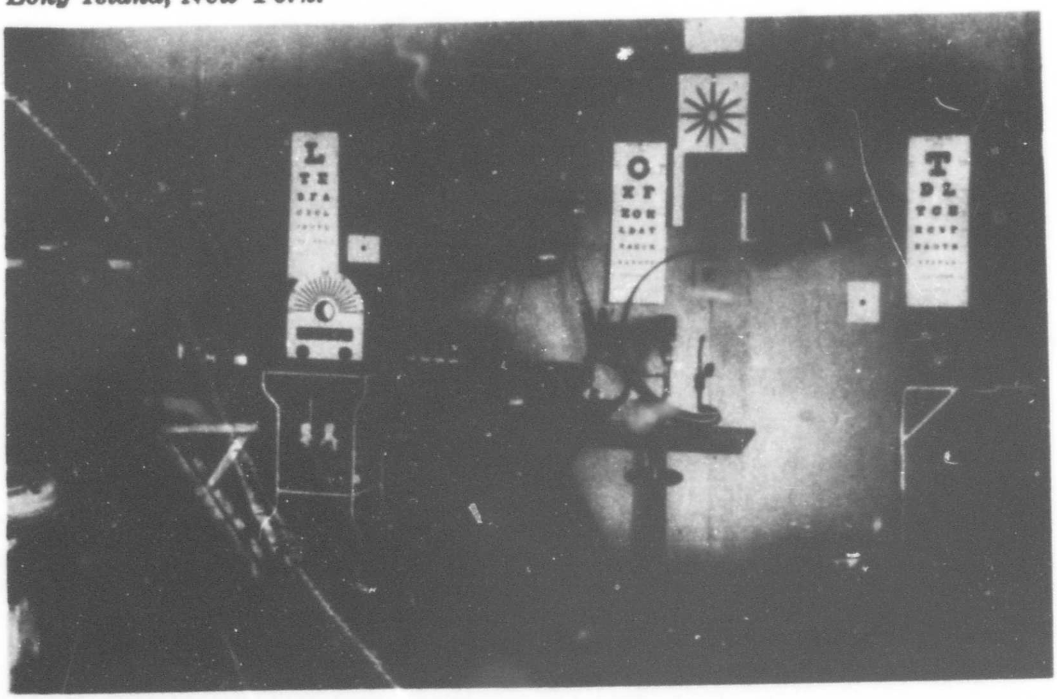

FIGURE 2 —

This Ophthalmology Laboratory at Hazelhurst Field, N.Y. was designed for conducting eye examinations on pilot candidates.

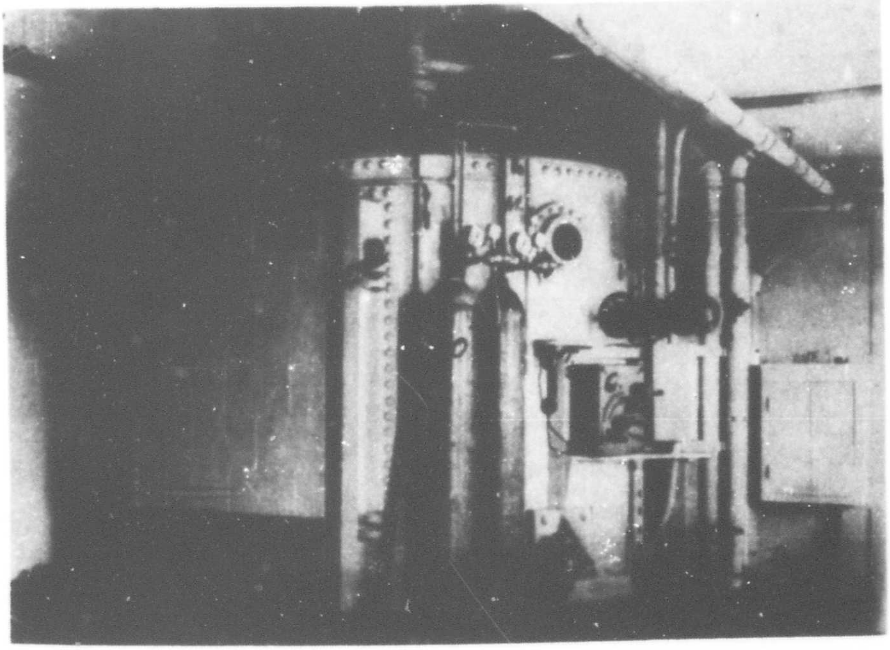

FIGURE 3 —

This low-pressure chamber was one of two used in the early years of aerospace medicine.

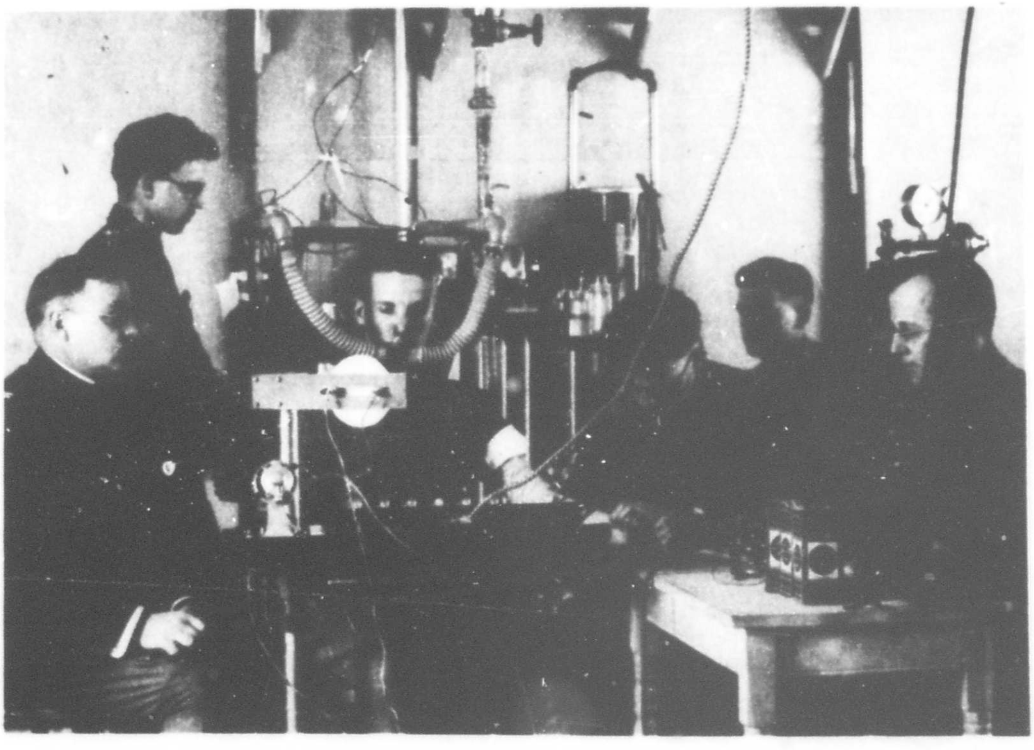

FIGURE 4 —

Doctors test a pilot's field of vision while he is in a state of hypoxia in the early Medical Research Laboratory.

Thus, the Medical Research Board—although it did not dissolve entirely—was transformed into the Medical Research Laboratory, much as a butterfly evolves from its chrysalis. The Board preserved a shadowy existence as the official agency from which the Laboratory derived its powers. But in fact the powers were assumed by the Laboratory itself. Henceforth, this organization was to be the prime source of scientific knowledge and procedural doctrine for the treatment of medical conditions peculiar to flight. In no other branch of medicine, before or since, has the discovery of basic principles, together with their application in teaching and practice, been associated so long or so intimately with a single institution.

No sooner was this project well under way than Colonel Lyster boarded a troop ship in Hoboken, New Jersey, and sailed with a convoy bound for Europe.[26] He was accompanied by Isaac Jones, who had now been promoted to major. They spent the next five months overseas, visiting aviation units at the front and behind the lines in France, Italy, and England, collecting first-hand information on Allied experience with medical problems and the facilities available to treat them.

At Aviation Headquarters in Paris they found the answer to one of the quests imposed upon the Medical Research Board by the War Department. It was an oxygen regulator, a practical device that supplied supplementary oxygen automatically to flyers at high altitudes. Designed by Lieutenant Colonel Georges Dreyer, a medical officer with the Royal Flying Corps who was in private life Professor of Pathology at Oxford University in England, it was then being fabricated by hand, one unit at a time, by a small instrument shop in Paris. Lyster and Jones sent the device to a manufacturer in Chicago with a $700,000 order to reproduce it in quantity for the American and Allied air services.

Meanwhile, in Washington, Major Wilmer and his colleagues waited for the completion of a building to house the new Laboratory at Hazelhurst.[27] During the last two months of 1917, they drew up detailed operating policies and plans; prepared a budget and procured Army funds to finance it; recruited more medical, scientific, and administrative talent to assist them; and ordered research equipment, much of it novel in design and for esoteric uses.

In whatever time was left, they improvised experimental studies to serve as a foundation for the more exhaustive investigations which they were planning to pursue later. For these preliminary inquiries the Bureau of Mines provided space in a small and ill-equipped laboratory at American University in Washington.

In laying out its research program, the Board already had arrived at a significant conclusion.[28] While a variety of unfamiliar forces and effects influenced the reactions of the aviator aloft—among them the exceptional speed of flight, the responsiveness of the craft to gravitational attraction, the added dimension of height with its deceptive optical effects, the difficulty of maintaining proper balance in the absence of a solid surface for support, the erratic motions produced by unseen air currents, and the varying pressure of the atmosphere on the body—one in particular was considered paramount. It was the rapid diminution in the amount of life-sustaining oxygen present in the air at increasing altitudes.

Oxygen deficiency, followed by confusion or loss of consciousness, was thought to account for many otherwise unexplained accidents in flying. The obvious remedy was to determine the progressive effects of oxygen starvation on all the relevant functions of the human body, in order to counteract them.

The problem in trying to study any of these processes in flight, where they occurred, was the fact that the open-cockpit airplane was small and unstable, in constant transition from one altitude or condition to another. For strict control of the experiment, it was necessary to reproduce the flight medium in a laboratory securely stationed on the ground.

Major Wilmer's staff possessed one ingenious apparatus for this purpose.[29] It was the Henderson-Pierce Rebreather, designed and built by the Yale physiologist with the aid of a versatile young officer who also was from Connecticut. Lieutenant Harold Fisher Pierce was a graduate of Clark University in Massachusetts who had worked for a year with the General Electric Company in an electrical engineering and chemical test laboratory. He had then become an instructor in chemistry at Dartmouth College, and had gone on to a teaching fellowship in physiology at Harvard University before he was commissioned in the Army Reserve.[30]

After the War, Pierce would spend three years at Oxford University with Dr. Georges Dreyer, earning another baccalaureate degree in science; would take his doctorate of philosophy in

physiology at Columbia University; and finally, at the age of 45, would receive his diploma as a doctor of medicine from the Johns Hopkins University. Even in 1917, his knowledge of engineering, combined with his training in chemistry and physiology, made him an invaluable assistant to Professor Henderson.

The Henderson-Pierce Rebreather was as simple as it was ingenious.[31] A closed container filled with air was connected by a tube to a can of sodium hydroxide (caustic soda). Another tube led from the can to a mouthpiece. With a clip on his nostrils, so that he could not breathe the atmosphere around him, the subject inhaled through the tube from the air in the container and exhaled through the tube into the container again.

With each breath of inspired air, a certain amount of oxygen was absorbed into the subject's blood stream and tissues. With each expiration, the carbon dioxide from his lungs was absorbed as it passed through the can of caustic soda. If he started with a tank containing 60 liters of air, of which 21 per cent (or 12.6 liters) was oxygen, the average subject in half an hour would reduce the oxygen to approximately one-third of that amount (4.2 liters) after removing 8.4 liters from the air.

But the proportion of oxygen in the atmosphere was constant up to altitudes far higher than any attained at that time. So reducing the amount of oxygen to one-third was compatible in this respect to an ascent in an airplane to an altitude at which the atmospheric pressure as a whole was about one-third of the pressure at sea level. The equivalent altitude was 27,500 feet, or 5.2 miles.

Using this apparatus at the makeshift laboratory in Washington during the final weeks of 1917, the staff of Colonel Lyster's new research institution examined the effects of oxygen deprivation at different altitudes on the respiratory system, on the heart and circulation, on the mind, on vision, on hearing and the motion-sensing functions of the ear, and on the personality of the aviator.[32] In general, the effects were usually small, and seldom noticed, until the point of asphyxia approached somewhere above 18,000 feet (3.4 miles). Then the functional deterioration was rapid.

These results were published ten months later by the *Journal of the American Medical Association*, in a series of seven papers edited by Yandell Henderson. The authors were Henderson and

Seibert (organization and procedures), Schneider (physiology), Whitney (cardiovascular system), Dunlap (coordination and attention), Wilmer and Berens (the eye), Lewis (the ear), and Paton (personality).

When this work was done, the Medical Research Laboratory had not yet opened up for business. But it had produced the substance of its first authoritative publication. On this foundation all of its future research would rest.

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Chapter 2

MOUNTAIN SICKNESS

Before 1917, the origin of aviation medicine could be traced back for six centuries or more.[1] It had started with the first recorded inquiry into the properties of air at high altitudes. The nature of this transparent ocean of gas that covered the Earth—or even its tangible existence—was then unknown. Yet the atmosphere reaching upward from the plains and meadows near the sea was a separate environment which aviation was to share with two earlier modes of human travel: balloon flight and mountain climbing.

Ancient people had felt little enthusiasm for the grandeur of remote and lofty places. In mountain regions they had lived mostly along river valleys and on the gentler slopes of the foothills. The towering fastnesses above were considered lonely, sinister, and the haunt of inhuman creatures. When it became necessary to traverse those desolate ranges of ice and rock, they clung to the lower passes, rarely ascending more than about a mile. Any ill effects of the climb were attributed to fatigue, to the intense cold, or to lack of nourishment.

The renaissance of knowledge and discovery in Europe brought a revival of curiosity about inaccessible areas and the more mysterious processes of nature. Travelers set out for distant lands, making notes on what they saw along the way. In the year 1298, Marco Polo crossed the high Pamir plateau in Central Asia, ascending to an elevation of 15,000 feet or so.[2] He made no mention of the effect upon himself or his companions. But he observed that fire burned with less than its usual warmth and brilliance, and that food took longer to cook. He thought that the cold was responsible.

Later travelers in high places were troubled by symptoms such as headaches, shortness of breath, unreasonable elation, vomiting, or a peculiar feeling of languor and detachment.[3] This vague in-

disposition came to be known as "mountain sickness." It was thought to be the effect of odd vapors or emanations from the ground. In South America the inhabitants referred to it as *la veta*—literally a vein in rock or the grain in wood—or as *mareo de la cordillera*, "seasickness of the mountains." The same malady was called by a variety of local names in Asia.

A Jesuit missionary, Father José de Acosta, who had traveled widely over the Andes Mountains of Peru, seems to have been the first person to suspect that mountain sickness was associated with the rarefied air on these majestic heights.[4] In his book, *Historia natural y moral de las Indias*, published in Sevilla in 1590, Father Acosta wrote: "There is no doubt that the cause of this distress and strange affliction is the wind or the air current there. . . . I am convinced that the element of the air in this place is so thin and so delicate that it is not proportioned to human breathing, which requires it denser and more temperate."

Half a century later, the great Italian astronomer and physicist, Galileo Galilei, demonstrated for the first time that air was a material substance with ordinary physical properties.[5] He did it by the classic method of weighing a hollow sphere of copper, first empty and then filled with compressed air. With air in it, the sphere was heavier.

In 1643, after Galileo's death, his former pupil and assistant, Evangelista Torricelli, worked out the principle of the barometer. Torricelli showed that the weight of the Earth's atmosphere, resting on the surface of a pool of mercury in an open vessel, exerted enough pressure to maintain a column of the same liquid at a height of about 30 inches (706 millimeters) above it, in a tube which was closed to form a vacuum.

A few years after this discovery, a French investigator, Florin Périer, proved that the pressure of the atmosphere decreased with altitude.[6] Périer carried a barometer up to the summit of the Puy de Dome, a 4,806-foot mountain in France. As he climbed, the height of the mercury in the column dropped until it measured only about 25 inches (637 millimeters).

Together, these three observations changed the concept, previously held by most philosophers, that air was an elemental principle of nature, immaterial but universal, existing everywhere

above the ground. Now it was apparent that the atmosphere, like the sea, was in fact a fluid medium; that less of it remained as one ascended through it; and that therefore it must terminate at a surface somewhere overhead, perhaps beyond the peaks of the highest mountains. Human beings now were seen to live on the bottom of this tenuous ocean.

Another century went by before an English chemist, Joseph Priestley, who also was a Nonconformist minister, found in 1774 that the vital component in air was oxygen.[7] A French chemist, Antoine Laurent Lavoisier, confirmed the earlier belief that respiration in living organisms was a form of combustion, releasing energy in the body. Lavoisier propounded a theory that this process resulted from the union of oxygen with other chemical elements.

At about the same time an English physicist, Henry Cavendish, determined the approximate proportions of oxygen and nitrogen in the atmosphere.[8] Further, Cavendish demonstrated that the gas was a simple mixture, rather than a chemical compound of its elements, and that the proportions were constant, regardless of the volume or the pressure. Small amounts of argon, carbon dioxide, and water vapor also were found in the air.

Only nine years after the discovery of oxygen, on June 5, 1783, the first flight in a captive balloon was made in France by the brothers Joseph and Jacques Montgolfier.[9] By the end of the year, half a dozen flights had been launched by several enthusiasts, three of them in untethered balloons. The last of these ascents was to a height of 9,000 feet.

In November 1784 the first scientific flight was made in a balloon to study the properties of the atmosphere.[10] The leader of this expedition was an American physician, Dr. John Jeffries, with a French balloonist, Jean-Pierre Blanchard, as the navigator.

Doctor Jeffries was a native of Boston and a graduate of Harvard College. He had studied medicine in England and Scotland, receiving his degree in 1769, at the age of 25. He had then gone home to practice medicine in Boston.

A British loyalist during the American Revolution, Jeffries had given up his practice after two years and had accepted a com-

mission as a surgeon aboard a British man-of-war. Later he had served in military hospitals at the British base in Halifax, Nova Scotia.

The death of his wife in England, where she had been living with their children, had moved Jeffries to resign his commission and return to London to practice. He was still there in 1784, when he heard about the balloon flights in France and conceived the idea of making an ascent himself. He was then 40 years old.

Doctor Jeffries paid Blanchard 100 guineas to take him up in a balloon over London. They cast off on the morning of November 13. Jeffries carried with him a barometer, a thermometer, an electrometer to detect changes in the air, a hydrometer to measure the specific gravity of the air, and six small vials of distilled water. During the 81 minutes of the flight, the vials were emptied one by one and the water replaced by samples of the atmosphere for analysis.

The barometric pressure dropped from 30 inches to 21.25 inches of mercury, showing that Jeffries and Blanchard reached an altitude of approximately 9,250 feet. The temperature went down from 51° to 28.5° Fahrenheit. The hydrometer fluctuated, but the electrometer showed no change.

Jeffries carried a note addressed to a friend in London. While he was aloft he dropped it over the side, and it was duly delivered. Thus Jeffries became not only the first flying physician and the first investigator to collect scientific data in flight, but also the first person to carry air mail.

He found the experience so exhilarating that he contracted with Blanchard for another balloon flight, this time across the English Channel. They launched the gas bag with its gondola from the cliff at Dover early on the afternoon of January 7, 1785, and caught a fair wind. They came down in midafternoon near the town of Guines (famed as the site of the Field of the Cloth of Gold, where King Henry VIII of England had once met with King Francis I of France for a parley), twelve miles inland from Calais.

To his other distinctions, Jeffries added the feat of having made the first overseas crossing by air. Besides, his published account of these flights was the first book on aeronautics.[11]

After Jeffries, as balloon flights became more common, studies of the atmosphere and its physiological effects picked up momentum. Beginning in 1799, the great German naturalist, Baron Alexander von Humboldt, traveled for five years through the mountain regions of South America and Mexico, recording observations in half a dozen areas of science, including meteorology.[12] Humboldt made careful measurements of barometric pressures and percentages of oxygen at high altitudes. He described mountain sickness as a consequence of reduced pressure and insufficient oxygen, but was unable to explain how the reaction occurred.

In 1835 a French physician, Dr. Victor Theodore Junod, developed the first low-pressure chamber, an apparatus capable of producing a partial vacuum in a laboratory on the ground.[13] It was a copper sphere about 50 inches in diameter, in which an experimental subject or a patient could sit, with a pump to exhaust the air inside. Doctor Junod used it both for clinical research and to treat disorders which were thought to be improved by a reduction in air pressure.

A clear explanation of the way in which mountain sickness acted on the human body was suggested for the first time in 1861 by another French physician, Dr. Denis Jourdanet.[14] A man of independent means, Doctor Jourdanet had traveled in the highlands of Mexico. Like Humboldt, he had filled his notebooks with observations of the climate and its influence on the inhabitants.

His medical knowledge enabled Jourdanet to compare the effects of altitude—for which he coined the term "anoxemia"—with the ordinary symptoms of anemia, and to propose a reason for the similarity. Over a period of fourteen years, he developed this theory in three books of his own.[15]

Briefly, Jourdanet noted that the reduction of atmospheric pressure with altitude decreased the amount of oxygen in the bloodstream, just as bleeding diminished the amount of oxygen by the loss of corpuscles. At moderate altitudes, up to perhaps 4,500 feet, the removal of excess carbon dioxide from the lungs would more than offset the slight decrease in the supply of oxygen, so that these elevations would exert a tonic effect on the traveler, as they did on patients suffering from anemia. But above 6,000 feet or so, the lack of oxygen would become increasingly debilitating.

Among Jourdanet's friends in Paris was a young physician of exceptional brilliance, Dr. Paul Bert, whose interests were remarkably varied.[16] Doctor Bert had first studied engineering; had then turned to law, passing his bar examination; had presently become bored with law and had studied medicine, taking his degree in 1863, when he was 30. An ardent republican during the Second Empire of Louis Napoléon, he was also active in politics.

Bert was a protégé of the great physiologist, Professor Claude Bernard. His thesis on the grafting of animal tissues, completed in 1865 and published a year later, won him the prize in experimental physiology from the Academy of Sciences in Paris and brought him to the attention of Jourdanet.

For several years, Bert taught zoölogy at the Faculty of Sciences in Bordeaux. While he was there, he worked on the physiology of respiration, the same field in which Jourdanet was interested.[17] In 1868 they made a compact.[18] Jourdanet was to provide the money that Bert needed to carry on his research. In return, Bert would concentrate on laboratory experiments dealing with the effects of changes in barometric pressure on plants and animals.

In December 1869, Professor Bernard resigned the chair of physiology at the Faculty of Sciences in Paris—one of two teaching posts which he held—and Paul Bert succeeded him. With a well-appointed laboratory and financial backing for the special equipment he required, Bert now began the intensive studies of barometric pressure and its action on the blood and tissue of the respiratory system that were to occupy him almost to the end of the next decade.

While he pursued this work, he managed also to participate in public affairs.[19] When the Franco-Prussian War ended in 1870 with the departure of Napoléon III and the restoration of the Republic, Bert was rewarded for his services with a government office as administrator of the Préfecture du Nord. In 1871 he was elected to the Chamber of Deputies.

In his experiments, Bert used a pair of large decompression chambers of his own design.[20] Each was an upright metal cylinder with a dome-shaped top, 6.57 feet tall and 3.285 feet in diameter, with a capacity of approximately 54.75 cubic feet of air. The two

chambers were joined together by a hatch, so that one was in effect an inner compartment while the only outer hatch was in the other. They were furnished with several glass portholes for observation and to admit light. The equipment inside included a tube to supply additional oxygen to the subject from a source outside. On the outer walls were manometers to show the interior pressure, thermometers, and controls.

With his pumping system, in 10 minutes Bert could reduce the air in the chambers from 760 millimeters of mercury (Hg), the mean pressure at sea level, to 360 mm Hg, approximating an altitude of 19,000 feet. In 20 minutes he could reduce it to 250 mm Hg, equivalent to an altitude of about 27,500 feet. Taking supplementary oxygen, Bert subjected himself to this pressure altitude. It was difficult to reduce the pressure any more, but he succeeded a few times in reaching 170 mm Hg, the atmospheric pressure at 36,000 feet.

By opening the valve into an auxiliary container, from which the air had been exhausted in advance, Bert was able to obtain a nearly instantaneous decompression. The object of these experiments was to study the mechanism of caisson disease ("bends"), the sometimes fatal illness from which men working below the surface of the Earth in mines or in diving bells often suffered, when they made a too-rapid ascent from a pressure of several atmospheres to the pressure of 1 atmosphere at the surface.[21] The same effect of course would follow from a swift rise to a great height in a balloon. But Bert could not confirm that this infirmity was caused by the release of nitrogen bubbles in the blood. It was one of few instances in which he failed to grasp a basic principle of human physiology in flight.

Altogether, Paul Bert performed 670 individual experiments on animals and men in the course of his research.[22] The subjects included a pair of balloonists, Joseph Crocé-Spinelli and Theodore Sivel, who visited Bert's laboratory in 1874 to test the effects of lowered atmospheric pressure in preparation for an attempt to set a new altitude record.

Bert sponsored their flight in the balloon *Zenith* on April 15, 1875, with Gaston Tissandier, who was to record scientific observations. Although they carried a supply of oxygen with them, all three lost consciousness before they were ready to use it. The

balloon soared to 28,820 feet—almost the height of Mount Everest—and then descended of its own accord. Crocé-Spinelli and Sivel both were dead. Only Tissandier survived to describe the experience.

In 1878, Bert published a monumental account of his studies, *La Pression Barométrique*.[23] With 1,178 pages, it was a model both of industry and of order in its logical presentation of the subject. The first 522 pages contained a historical review of all the relevant data compiled up to that time. The next 518 pages described the experiments and the conditions under which they were conducted. In the final 118 pages, Bert summarized all these findings and drew his conclusions.

La Pression Barométrique was Paul Bert's last important contribution to medical science. It was little noticed until after the rise of military aviation, forty years later. In 1881, Bert became Minister of Education in the cabinet of French Premier Léon Gambetta.[24] (During the siege of Paris in 1870, Gambetta had escaped in a balloon to found the Third Republic.) After the fall of the cabinet and Gambetta's death the next year, he obtained another vacant chair in the Academy of Sciences.

In 1886, Bert was chosen to reorganize the administration of the Province of Tongkin, comprising the part of French Indo-China which is now North Vietnam. With an appointment as Resident General, he sailed for the Far East, arriving at Haiphong in June. After five busy months in Hanoi, he fell ill and died of dysentery on November 11. He was then 53. The report of his death in *Lancet* on November 20, 1886, said nothing about *La Pression Barométrique* and barely suggested that Paul Bert was a distinguished physiologist.

Until the eve of World War I, research on the responses of the human organism to very high altitudes had not been considered urgent. The practical use of balloons was primarily for observing the ground. Except to establish records, they rarely ascended beyond 10,000 feet, where the effects of reduced oxygen were mild. The loftiest mountain peaks in Europe and the United States were under 16,000 feet. They had all been climbed before 1900, as had Orizaba (18,700 feet) in Mexico and Chimborazo (20,561 feet) in Ecuador. The physiological reactions had sometimes been severe but never insurmountable.

The highest altitude reached by an airplane, late in 1913, was 20,010 feet. It was this achievement that had led directly to the demand for more information on the difficulties that aviators might encounter at such heights. The remote summit of Mount Everest (29,002 feet) would not be scaled until 1953, and then only with the aid of techniques developed by aviation medicine.

The composition, density, volume, and pressure of the Earth's atmosphere up to about this level were reasonably well known from direct observation.[25] On the evidence of the Aurora, the refraction of light, morning and evening twilight, and the vaporization of meteors, it was thought that the atmosphere might extend to 100 miles above the ground. Beyond this point, it had been suggested that there might be another atmosphere of great rarity, consisting of dissociated gas particles in a state of equilibrium, so that its additional weight was not felt at the ground.

The total mass of the atmosphere had been calculated with some exactitude. Thanks to Paul Bert and others, the rapid diminution of its density and pressure—to one-half at about 18,000 feet (3.4 miles), to one-third at about 27,500 feet (5.2 miles), and to one-tenth at about 52,800 feet (10 miles)—also was known. Above 20 miles the pressure curve was not extended, "owing to uncertainty as to conditions in the upper atmosphere." This, then, was the largely undiscovered ocean of air upon which the aviator had launched his frail craft.

Up to this time, virtually all the significant advances in knowledge about the atmosphere and its effects on human beings had been made by European scientists. But the energies of Europe now were engaged in an enervating struggle between nations, from which it would take many years to recover. Only in America was there a vast surplus of manpower and talent, sufficient not only to resolve the issue of the War but also to carry on basic studies in the fields of aeronautics, meteorology, and the medical effects of flight at increasing altitudes.

That is why, in 1917, leadership in the new science of aviation medicine passed to the United States, where it was to remain for the next half-century or longer.

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Chapter 3

THE FLIGHT SURGEON

On January 19, 1918, at Hazelhurst Field, New York, the Medical Research Laboratory of the Army Signal Corps became a functioning institution.[1]

Its first home was a one-story frame building of the kind put up in haste by the Army at most new training camps and fields, to serve impartially as offices or barracks. With four department heads and a dozen other medical and administrative officers, Major Wilmer moved in and took charge formally of the operation which he had organized already in Washington. The rest of the staff reported within the next few days.

The winter of 1917-1918 was unusually cold. The small communities around Mineola—including Garden City and Hempstead—were filled with transient military people assigned temporarily at Hazelhurst. The young scientists and doctors found quarters where they could. Most of them had to travel a considerable distance to reach the Laboratory in the morning and their homes at night.

On the 21st, a Monday, they arrived at the Laboratory to find that the boiler of the steam heating plant had broken down. They requisitioned oil stoves. Even so, for the better part of three weeks while the boiler was being repaired, they carried on their experiments in temperatures ranging down to 22° Fahrenheit.

The most impressive piece of equipment in the Laboratory was a low-pressure chamber, the first in America and the largest of three then known to exist in the world.[2] Designed by Professor Henderson with the help of the chief engineer at the Bureau of Mines, and built by the Lancaster Iron Works in Lancaster, Pennsylvania, it was a single upright cylinder of steel a half-inch thick,

convex at the top and bottom, weighing 4 tons. It was delivered in February, after a long delay at a bridge that had to be shored up before the authorities would allow the truck to cross.

Henderson's chamber was nearly 10 feet tall at the center and 8 feet in diameter. Its capacity was about four times that of both the twin chambers in which Paul Bert had performed his classic studies. Thus it was roomy enough to hold several persons with a bulky apparatus such as the Barany Chair, the whirling seat developed by a Nobel Prize-winning Austrian physician, Dr. Robert Bárány, as a test for the sense of equilibrium.

The advantage of the chamber over the Henderson-Pierce Rebreather was that it exposed the subject both to reduced oxygen and to lowered atmospheric pressure, as they were encountered together at high altitudes. Although the flyer's difficulties had been blamed almost exclusively on oxygen deficiency, the behavior of oxygen and other gases in the bloodstream and tissues could be affected as well by variations in air pressure.

So the Laboratory's experiments in the early months of 1918 were a continuation and a refinement of the basic studies which it had made in the late fall and winter of 1917. They were reflected in an increasing number of papers by staff members in medical and scientific journals. In addition to the comprehensive report in the *Journal of the American Medical Association,* there were half a dozen such contributions in the first year of the Laboratory's existence.[3]

Also in these early months, the staff compiled the first official publication of its own. Edited by Wilmer, with sections from each of the six departments, *Manual of Medical Research Laboratory* became a volume of 255 pages issued by the Government Printing Office later in the year.[4] It reviewed the knowledge accumulated up to that time on the medical problems of flight, and described the procedures adopted by the Laboratory to investigate them.

Intended as a guide for medical examiners and for other physicians concerned with the flyer's health and safety, the *Manual* should be regarded as the earliest effort to provide a comprehensive text on aviation medicine.

In spite of the weather and the daily distractions at a busy pilot training base, within a month the Laboratory had progressed so far with its inquiries that it was ready to extend its work to

other flying schools around the nation, applying it in clinical practice.[5] On February 11, the Medical Research Board met and decided to open a branch of the Laboratory at each of the twenty flight instruction centers then in operation.

The Army now had so many qualified pilot candidates awaiting their turn to be trained that it had just suspended its aviation recruiting program.[6] The Laboratory dropped all of its studies aimed at refining the selection test for applicants, and concentrated thereafter on basic problems related to the care of flyers in training and after their graduation.

Early in March, Colonel Lyster returned from Europe with Isaac Jones.[7] They brought with them another concept new to aviation: the idea of a medical officer who not only would watch over the flyer's health and physical fitness, but would serve beside him as well, in the capacity of a friend, a knowledgeable companion in arms, and a trusted advisor.

This thought had come to them while they were touring the fronts in France and Italy. It had been suggested by the remarkable success of a few military physicians whom they had met—notably Dr. James L. Birley of the British Royal Flying Corps and Dr. Ralph H. Goldthwaite, one of the first Americans overseas—in establishing a relationship of mutual confidence with the aviators under their professional care. The Chief Surgeon had resolved to make this relationship an official one in the Army Signal Corps.

With Isaac Jones, on their way home, he had analyzed the requirements which would have to be met. First of all, the medical officer would need a specialized course of training in the unusual conditions to which aviators were exposed. At only one institution was this knowledge now available: the Medical Research Laboratory at Hazelhurst Field. It would be necessary to enlarge the Laboratory, so that its staff could give this instruction.

Secondly, the medical officer should be an actual member of the flying unit—the squadron or air group—in which his work was to be performed, sharing directly in its operational activities, and not merely a physician assigned to this duty in the hospital or dispensary at the field where the unit was then based. Hence, a position would have to be created for him, with a distinctive title and with specific responsibilities as an assistant and advisor to the squadron commander.

Finally, it was essential that the medical officer should understand the temperament of the flyer, should speak his eclectic language, should enjoy his personal respect and trust. To this end, it was desirable that the doctor should have some personal experience in the air, if not as a pilot himself, then at least as an observer who accompanied the pilot on occasional missions. In that case, like the aerial gunner or the bombardier, he would need a designation that permitted him to fly.

Up to this time, only one Army medical officer was known to have received orders accrediting him as a military aviator. He was Major Ralph N. Greene, a neuropsychiatrist from Florida, who had served on the Mexican border with the Third Aero Squadron in 1916 and had learned to fly with Eddie Stinson, an early aviation enthusiast.[8] A few others—including Isaac Jones—had taken lessons before they were called into active service as medical officers. From now on, all squadron physicians would be expected to participate in flights as a facet of their regular duties.

While Lyster, with his usual energy, worked out the organizational details, drafting orders and regulations and explaining them to the authorities in Washington, Isaac Jones looked around for men qualified to fill the new positions, and arranged with the Laboratory to devise a course of instruction.[9] To Jones also was left the task of conceiving a title which would adequately describe this novel kind of duty.

At Hazelhurst one day Jones was discussing the nature of the duty with his fellow otologist, Major Eugene R. Lewis. They observed that all military doctors from time immemorial had been known as surgeons. And then the title came to them. Henceforth, the aviator's personal physician would be called the Flight Surgeon.

The Army's decision to suspend the recruiting program for flyers had left a number of aviation medical examiners available for other duties. Jones had himself selected many of these doctors, and he knew their qualifications. From the list, he singled out forty or more, and had orders issued assigning them to the Laboratory for training.

Lieutenant Colonel Wilmer (he was promoted in March, and was to be promoted to Colonel in June)[10] called his staff together and improvised a hasty graduate course in aviation medicine. Relying

heavily on practical demonstrations of experiments carried on by the Laboratory, it would follow an irregular schedule lasting four or five weeks.[11] Some flight instruction was to be provided by the flying school at Hazelhurst.

The Laboratory now was only two months old, and it was on the point of bursting at the seams. While it made ready to receive the student flight surgeons, it was training medical officers to operate the twenty branch laboratories which were to open in June. Besides, it had been asked to prepare a course for physical directors, one of whom was to be sent into the field with each flight surgeon as an assistant, responsible for the health activities and recreation of pilots.

The redoubled burden of conducting all these classes made it necessary to enlarge the Laboratory. Toward the end of March, construction began on an addition which was to treble the size of the original building. Most of the new space was allocated to the teaching effort. Work started shortly afterwards on a barracks for the enlisted laboratory assistants.

On May 8, 1918, orders began to appear assigning graduates of the informal course at the Laboratory to duty as flight surgeons.[12] The term itself did not appear in the orders, nor were the duties defined. Instead, the doctors were instructed to report to the office of the Chief Surgeon in Washington, where the new designation and its responsibilities were explained.

The first of these assignments went to three young otologists, Captain John P. Gallagher, Captain Robert J. Hunter, and Lieutenant Claude T. Uren, all of whom had reported to the Laboratory for training in March. (Their names were published in Special Orders of the War Department No. 108, Paragraph 199.) On the way to his duty station, Captain Gallagher stopped off for a few days to visit his fiancée. Lieutenant Uren went by his home to inspect a new-born child. Captain Hunter proceeded directly to his assignment at Park Field, near Memphis, Tennessee. Thus, on May 13, he became the first medical officer ever to perform the duties of a flight surgeon.

The reason for the mystery surrounding their appointments became apparent later in the month. The aviation branch of the

Army was in the midst of a reorganization.[13] On May 21, by executive order of the President, all flying activities were transferred from the Signal Corps to the new Division of Military Aeronautics in the War Department. Together with the Bureau of Aircraft Production, on May 24 the Division became a part of the Air Service.

In this change of authority, Colonel Lyster's own position as Chief Surgeon of the Aviation Section disappeared.[14] His office reverted to its original status as a division under the Surgeon General, known as the Air Medical Service. He had been waiting until the reorganization took effect to make the title and the duties of the flight surgeon official.

On June 3, a memorandum from the War Department was forwarded to commanding officers and post surgeons at all stations where flight surgeons now were assigned, describing their functions and command relationships.[15] On only one important point had Colonel Lyster's plan miscarried: the flight surgeon still was under the nominal direction of the post surgeon, although for all practical purposes he was responsible to the commandant of the flying school or the squadron commander.

On June 6, by Special Order No. 132, the original orders assigning the first group of flight surgeons were amended to show that they would be known officially by this title. In the tables of organization issued to flying units, fifty flight surgeons (and the same number of physical directors) were authorized. One was to be assigned to each flying school in the United States, and the others overseas "as they were needed."

At this time, thirty-two flight surgeons had been designated.[16] (See the list in Appendix II.) One of them was Isaac Jones. Another was Colonel Ralph H. Goldthwaite, whose performance in France had been taken as a model of the services which the flight surgeon ought to render. He was then the only member of this élite company overseas. From the original staff of the Laboratory, one officer had been chosen. He was Major Henry W. Horn, another otologist. The rest were former medical examiners who had been brought in to the Laboratory for a month or so of training. All except Jones and one or two others were now dispersed about the country at flying schools.

Not all of the medical examiners summoned to the Laboratory had been named as flight surgeons—the quota was limited by the number of vacancies at the schools. Those who were omitted from the list had stayed on at the Laboratory, swelling its professional staff. By June, the total complement of the Laboratory had grown to more than a hundred officers and enlisted technicians.[17] Besides conducting research and teaching, they tested the individual responses of student flyers to altitude in the low-pressure chamber at Hazelhurst or in the Henderson-Pierce Rebreather at the branch laboratories.

This carefully planned organization for the study and clinical care of aviators had been fully in effect for only a few weeks when it was rudely shaken out of its absorption in its own plans. An urgent cable arrived in Washington from General John J. Pershing, Commander of the American Expeditionary Forces in Europe.[18] It was a request for the immediate dispatch of medical officers and equipment abroad, to investigate a sharp rise in accidental deaths among American aviators in the war theatre and to look for a means of reducing them.

Fleets of troop ships had been ferrying American flyers across the Atlantic in increasing numbers since August 1917, almost a year earlier.[19] But they did not arrive fully trained and ready for combat. On the contrary, most had received forty to fifty hours of primary flight instruction in the United States and then were given advanced training in combat aircraft at schools overseas. A few had never flown at all until they landed in France.

The American Air Service now had schools of its own in operation at a dozen or more fields in France. Of these, by far the largest was at Issoudun, 55 miles southeast of Tours in the rural département of Indre-et-Loire, the so-called "Garden of France." In fact, the training center at Issoudun was then the largest air base in the world.[20] Covering 36 square miles, it had nine separate flying fields and others under construction, with a complement of more than 5,000 officers, cadets, and enlisted men.

By now, though, the ardor with which aviators had taken to the air in the early years of the War had largely subsided. The frustration brought about by the long stalemate on the front, the vast numbers of men involved, and the high casualty rate had combined to subdue much of their light-hearted enthusiasm.

Among the Americans in training, there was now a fatalistic attitude toward the probability of being killed.[21] They believed that when the time came they would be "bumped off," no matter how many precautions they took nor how great was their skill.

Fatalities from accidents were three times as many as from enemy action. For every 721 hours flown, there were three crashes, of which one was fatal. At Issoudun, about 500 hours were flown daily. In August 1918 the number of deaths for the month mounted to 17, or nearly two each day, an increase in the fatality rate to almost 300 per cent. Except for half-hearted setting-up exercises before dawn, there was no physical training program.

Presumably to guard against malingering, the student flyer had to have express permission from his immediate commander before he could consult a medical officer. The Post Surgeon was authorized to recommend no more than two days' leave at a time for rest and psychic therapy. This was the situation that had led General Pershing to call for help from the Surgeon General.

The medical officer chosen to go to the flyer's aid was Colonel William H. Wilmer.[22] Without being relieved of his primary duty as commander of the Laboratory at Hazelhurst, he was appointed the ranking member of an overseas Medical Research Board like the one which had founded the Laboratory. Later, after he arrived in France, Wilmer became the Surgeon in Charge of Medical Research Laboratories for the Air Service of the A. E. F. As in the case of the branches at flying schools in the United States, they were considered off-shoots from the parent Laboratory at Mineola.

With Wilmer on the new Board were Lieutenant Colonel Leonard G. Rowntree, Professor of Medicine at the University of Minnesota, who had lately joined the Laboratory as a cardiologist; Major Edward C. Schneider, chief of Physiology at the Laboratory; and Major Henry W. Horn, then the Laboratory's only flight surgeon.

From the research departments of the Laboratory, the Board selected fourteen other specialists to conduct experimental studies and tests among the flyers abroad. (See Appendix III.) They included Major James L. Whitney, Captain Conrad Berens, Jr., Captain Harold F. Pierce, and several more junior members of the original staff.

From the flying schools to which they had reported only a few weeks before, sixteen flight surgeons trained by the Laboratory were summoned back to Washington and reassigned to Wilmer's mission. They were to reorganize the clinical evaluation and care of American aviators with the Army in Europe.

Composed entirely as it was of men who had been intimately associated with the Laboratory, this group of 34 medical officers and scientists was in fact an overseas detachment of the institute at Hazelhurst. It was divided into four teams. One would drop off in Britain, to work for a time with the Royal Flying Corps. Another would proceed to Vichy for temporary duty. The other two, with the Board itself, were to establish a headquarters at Issoudun.

All but one of these officers sailed from Hoboken on August 6, 1918. The exception was Captain Pierce. He was the troop commander in charge of fifteen enlisted technicians. Also, as the only member of the party with engineering experience, he was responsible for 14 tons of medical equipment.

The main piece of equipment was a low-pressure chamber similar to the one installed at the Laboratory in February. Designed by Pierce himself, it was smaller than the original by a foot in height and another foot in diameter, and incorporated certain technical improvements.[23] When the Board sailed, the steel chamber was nearing completion at the Lancaster Iron Works under Pierce's own supervision.

As soon as it was ready, Pierce and his men hauled it to Hoboken. Along with 84 boxes packed with rebreathers and other experimental and clinical apparatus, they loaded the metal cylinder aboard another transport, and sailed a week or so after Colonel Wilmer.

They were still at sea when the first death occurred in the small corps of flight surgeons trained by the Laboratory.[24] Not among those who had accompanied Colonel Wilmer to France, he was Major William R. Ream, one of the fourteen still on duty in the United States. On August 24, 1918, on a routine flight at Chanute Field, Illinois, Doctor Ream was killed in an airplane accident. With the others who were to follow him over the years, he would serve as a reminder that the flight surgeon's wings were not merely a decorative symbol.

On September 2, Colonel Wilmer and his group arrived at Issoudun. [25] The same afternoon, they toured the outlying fields, collecting data on flying conditions, aircraft accidents, and the health of the flyers. The next day, they plunged into their work. Within six weeks, they were able to report a really astonishing change in the morale and performance of their charges. During the month that ended on October 15, the student pilots had flown some 1,870 hours more than in any similar period in the past. For the twelve days since October 3, the hours flown had totaled 4,436 without a single fatality.

Less than a month after this achievement, the War was over. In a last powerful offensive, the German Army had broken out of the trenches, had reached the Marne again, and once more had fallen back. The so-called Hindenburg Line had given way in late September; the allies of Germany had surrendered one by one; the Kaiser had abdicated and taken refuge in Holland. On the morning of November 11, 1918, the Armistice was signed in a railway coach at Compiègne. For the first time in four years, the guns were silent on the Western Front.

Oddly enough, flying continued at Issoudun just as if the War had never ended, though at a somewhat more desultory pace. Hundreds of American aviators were on hand, waiting to be trained for aerial combats in which they would no longer be engaged. Schedules had been drawn up; orders had been issued and were not yet countermanded; routine housekeeping went on; and military discipline had to be maintained. Wilmer's laboratories pursued their studies, tests, and physical examinations, while they awaited guidance from the high command.

It had taken a year and a half to bring all these men together here in the countryside of France. It would take a while longer to get them all home again.

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Chapter 4

AFTER THE ARMISTICE

For staff members of the Medical Research Laboratory who were still at Hazelhurst, the winter after the War ended was as odd as it was for the detachment at Issoudun. From Lieutenant Colonel Edward G. Seibert, the acting commander, on down, all of these doctors and scientists were temporary officers in the Reserve. For that matter, with the exception of Colonel Lyster, every person who had been directly involved in the development of aviation medicine up to this time was a civilian specialist in uniform. Until the Armistice, they had been completely absorbed in exploring the medical problems of flight. Now that the War was over, they were increasingly distracted by thoughts of the careers which they had laid aside to join the Army.

It was the winter of the worldwide influenza epidemic. The worst contagion of its kind in history, it was estimated to have caused the death of more than half a million Americans and some twenty million victims around the globe.[1] (In France, Colonel Wilmer had suffered from a mild bout with influenza on his way to Issoudun, and was to suffer from a more severe one in January that kept him from traveling to Italy for an international conference on aviation medicine.)[2] To the concern of the staff for their careers and their future practice was added concern for the health of their families.

Nevertheless, the work went ahead, although at a diminishing rate of progress. Late in the year, the Laboratory received a new low-pressure chamber from the Lancaster Iron Works.[3] Designed by Harold Pierce, like the one which he had taken abroad with him, it was larger than either of its predecessors. Standing almost 10 feet tall at the center of its domed top and base, with a diameter of 9 feet, it had approximately 25 percent more capacity than Professor Henderson's original chamber. Besides, it was cork-insulated and fitted with refrigeration, so that experiments could be conducted in the extreme cold temperatures at high altitudes.

The new chamber replaced the old one, which was now outmoded. In early tests without occupants, it reached a simulated height of 75,000 feet (or 14 miles), roughly twice the altitude attained before in these laboratory vehicles, at a temperature of 31° below zero Fahrenheit (−35° Centigrade). The staff used it to refine still more their data on the physiological effects of reduced oxygen and atmospheric pressure, adding the factor of extreme cold.

By January, it was apparent that Colonel Wilmer would not be returning to the Laboratory. Together with most of the officers who had accompanied him to France, he had applied for his release from active duty. One by one, the staff members who remained at Hazelhurst submitted the same request. There was even some doubt that the Laboratory would survive at all, so rapidly was the wartime Air Service being dismantled.

The mission at Issoudun was recalled in February.[4] It packed up its equipment and departed on the 19th. Lieutenant Colonel Pierce went as far as England. There he was ordered to meet the low-pressure chamber at Oxford University, which had acquired it from the Army, and install it in the Department of Pathology. Released from duty in April, while he was still at Oxford, Pierce got along so well with Professor Georges Dreyer that he agreed to stay with him as a student and instructor in the Department.

Wilmer and the others arrived in New York in March. Wilmer went at once to Washington, which was his home as well as Air Service Headquarters.[5] After filing various official reports and receiving the Distinguished Service Medal from General Pershing, he was honorably discharged on May 15. He returned to his teaching duties at Georgetown University and resumed his practice as an eye specialist.

In 1921, Wilmer was promoted to Brigadier General in the Medical Corps Reserve. Shortly afterwards, a group of his patients and admirers formed the William Holland Wilmer Foundation and raised four million dollars to endow the Wilmer Ophthalmological Institute at the Johns Hopkins University in Baltimore. In 1925, Wilmer joined the medical staff at Johns Hopkins as professor of ophthalmology and director of the Institute. He was as eminent in Baltimore as he had been in Washington, until he retired in 1934.

Among his many other professional honors and achievements, Wilmer was a founder and fellow of the American College of Surgeons, President of the American Ophthalmological Society, and President of the Association of Military Surgeons of the United States. After a long and notable career as a teacher and clinical specialist, the first commander of what was in time to become the Air Force School of Aerospace Medicine died in Washington on March 12, 1936.

The successor to Wilmer in that post was a Regular officer of the Army Medical Corps and his junior by a quarter of a century.[6] Dr. Louis Hopewell Bauer, the son of a musician, was a native of Boston and a graduate of the Harvard University Medical School in 1912. After his internship, he had joined the Army medical service as a first lieutenant in August 1913. Lieutenant Bauer was an honor graduate of the Army Medical School in Washington, where he might very well have met Doctor Wilmer.

During the first years of the War in Europe, Bauer had served on the Texas border and in the Philippines, both traditional training grounds for Army surgeons. Recalled from the Philippines after the United States entered the War, he had been assigned to the new flying school at Kelly Field, on the southern outskirts of San Antonio, Texas. By February 1918, he had risen to the temporary grade of lieutenant colonel.

A year later, while his colleagues in the Reserve were hastening back to their civilian practices, Louis Bauer was appointed officer in charge of the Medical Research Laboratory at Hazelhurst. At the same time, he reverted to his permanent rank as a major. Bauer was then 30 years old and a promising Army surgeon, with some practical experience in the problems of aviation medicine. After a few weeks' leave, he took command of the Laboratory around the end of February 1919.

He found it in a state of considerable disarray. Most of the staff had either left or been awaiting orders to leave shortly. Few qualified replacements from the Regular Army were available, and none had yet arrived. With a handful of specialists who had decided to stay on for a while longer, Bauer was able to keep a semblance of research activity going in each of the professional departments.

From the group which had accompanied Wilmer to France he received one welcome addition. Major Edward C. Schneider was bent on pursuing his inquiries into the physiological effects of high altitudes. The low-pressure chamber which had recently been installed at the Laboratory was the most advanced piece of experimental equipment for these studies in the world. Mainly for that reason, Major Schneider resumed his old position as head of the Department of Physiology, the largest and most active department in research. He became a trusted friend and advisor to the new Commander.

The same uncertainty that afflicted the Laboratory was felt at Air Service Headquarters in Washington. Colonel Lyster was left virtually alone in the office of the Army Surgeon General to oversee the dissolution of the medical organization which he had conceived and built, and to salvage what he could from the remains. Isaac Jones had sailed for France in January to represent the medical service at the Peace Conference in Paris.[7] He was one of the drafters of an agreement with France, Great Britain, Italy, and Japan on International Requirements for Commercial Flying, and signed it (with Major James B. Stanford) for the United States.

At the War Department, aviation research and development—whether in the medical or the physical sciences—was one of the least pressing interests for the moment. The immediate problem was to reduce the Air Service as quickly as possible to the skeleton size that was characteristic of American military forces between wars. Within a few days after the Armistice, outstanding orders for 13,000 airplanes had been canceled.[8] For the next decade, the Army would make do with the planes it had left when the War ended. Many of these were to be sold as surplus to civilian flyers.

From a peak of almost 200,000 officers and men at the close of the War, the air arm was to be compressed to 24,000. Even this modest number would be cut by the Congress to 10,000 officers and men. Except for a few dedicated pilots who accepted commissions in the Regular Army—some of them, like Claire Chennault, James H. Doolittle, Ira Eaker, and George Kenney, to become renowned leaders in future campaigns—the airmen signed up in 1917 and 1918 were going back to civilian life as fast as they could. The peacetime force would have to be recruited all over again from a new generation of young men, dazzled as their elders had been by the glamor of aviation during the War.

The Army foresaw no difficulty in obtaining these men.[9] The difficulty would be to select the ones best qualified physically and mentally, and then to maintain their fitness while they were trained and afterwards. Like the pilots, virtually all of the medical examiners and flight surgeons chosen by Isaac Jones in 1917 and 1913 now were departing. To replace them, the Surgeon General published a circular letter on April 25, 1919, requesting volunteers from among the Regular Army's medical officers to serve as flight surgeons with the Air Service. The inducements included an opportunity to become pilots themselves, with a 25 per cent bonus in salary as flight pay.

The only place where flight surgeons could be trained in the specialized techniques of aviation medicine was at the Medical Research Laboratory. Early in May, Doctor Bauer received a telephone call from Washington.[10] The letter had brought in a number of applications already. The Surgeon General's office had selected a class of nine medical officers and was sending them to Hazelhurst for training as flight surgeons. Major Bauer was to see that they received an adequate course of instruction.

Like Colonel Wilmer before him, Bauer called in his department heads and put together a tentative curriculum. This time the class would be in session for two months. Again the teaching would rely heavily on research performed by the Laboratory since the fall of 1917; but now the material was to be organized into formal lectures. They would be supplemented by clinical studies of combat aviators who had just returned from France and were being processed for discharge at Mineola. The students also were to visit the wards and clinics at the neighboring Camp Mills Hospital and at Bellevue and other hospitals in the vicinity of New York City.

From this moment on, teaching began to dominate the work of the Laboratory. As the staff grew smaller, preparing lectures and conducting demonstrations occupied a larger proportion of its effort. Research continued, but in diminishing volume and in such time as the instructors could spare between classes. After 1919, when the number of papers by staff members appearing in professional journals reached a maximum of nineteen (excluding official publications of the Air Service itself), they dropped off gradually until, in 1925, there would be only five.[11] Increasingly, these papers were oriented toward the practical duties of the flight surgeon, particularly in examining, classifying, and selecting flyers.

Despite this change in its primary function, the future of the Laboratory now was assured. The War Department had reaffirmed its need for a continuing corps of flight surgeons to keep watch over the aviator's fitness, and had recognized the Laboratory as the institution where they were to be trained.

Whether because he felt that he had carried this work as far as he could or for more personal reason, the chief architect of aviation medicine now decided to part company with it.[12] In the spring of 1919, Colonel Theodore Charles Lyster asked to be retired from active service after nineteen years in the Army. With Isaac Jones (who had by now returned from the Peace Conference) he went to Los Angeles, California. There, in 1920, they entered private practice together as eye, ear, nose, and throat specialists. Lyster then was 44.

In August 1930, a special act of Congress tardily raised him to the rank of brigadier general in the Reserve. On August 5, 1933, at the age of 58, he died. Although Lyster had taken little part in the development of aviation medicine since the War, he was acknowledged as its founder. Without his imaginative idea of a uniquely sympathetic relationship between the flyer and his physician, neither the Medical Research Laboratory nor the flight surgeon would have existed.

His replacement as head of the air division in the Surgeon General's office was Colonel Albert E. Truby, like Lyster a career surgeon of the Regular Army.[13] When the division was returned to operational control of the Air Service not long afterwards, Colonel Truby was appointed Chief Surgeon of the Air Service, a post comparable to the one that Lyster had held for a while in the Aviation Section of the Signal Corps. From this time on, under one title or another, the air arm of the United States was to have its own medical service.

On July 16, 1919, the first formal class of flight surgeons was graduated by the Laboratory.[14] They included Captain David A. Myers, who was to serve two decades later in the position that Colonel Truby now held.[15] Another was Captain Charles T. C. Buckner. Eight years later, in 1927, Doctor Buckner would be the fourth flight surgeon to be killed in an airplane accident.[16]

The second class, also with nine students, began immediately. It was graduated on September 15, 1919. None of its members was to become the medical chief of the air arm, and none was to die

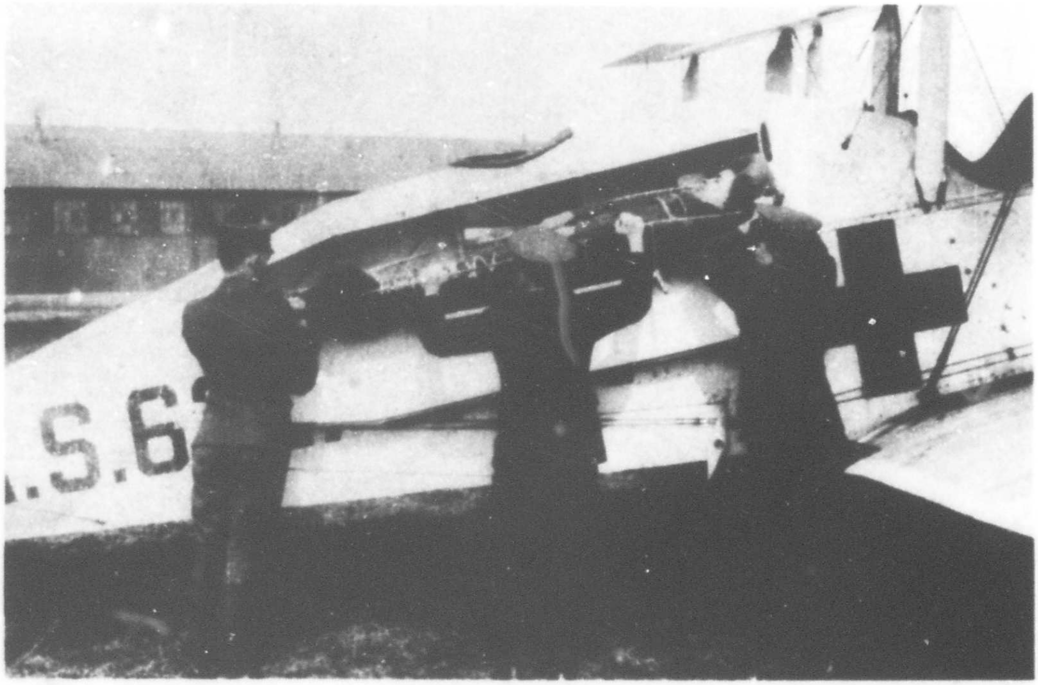

FIGURE 5 —

A patient is put aboard an air ambulance of 1920. This is one of the first types of air evacuation aircraft.

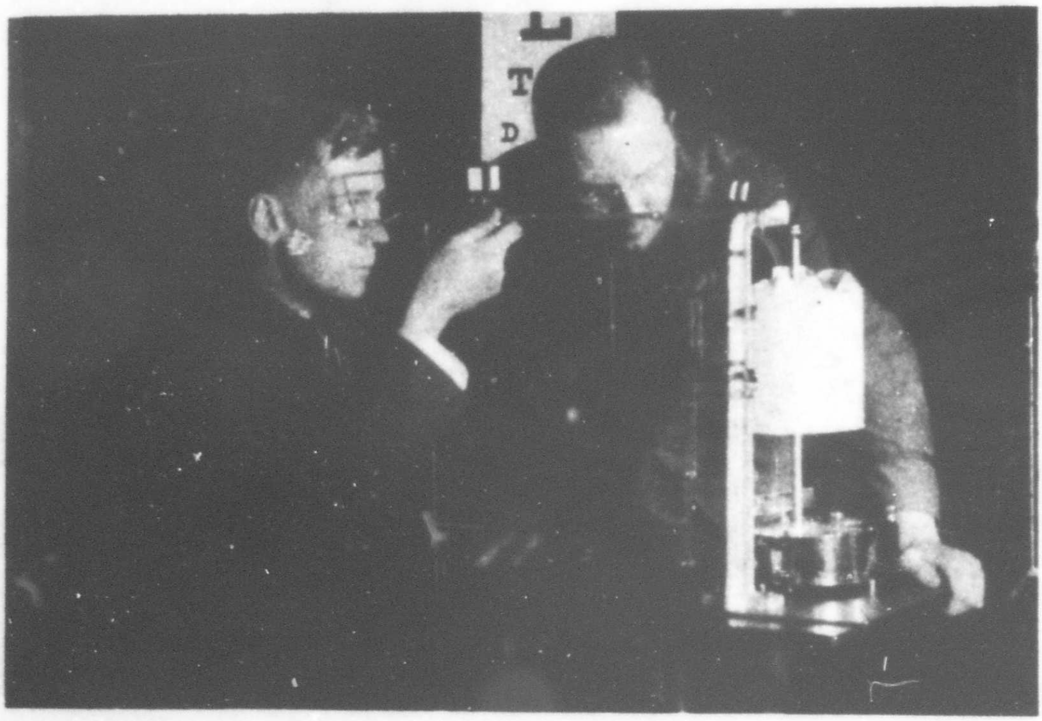

FIGURE 6 —

A pilot undergoes eye tests in early ophthalmology studies at the School of Aviation Medicine.

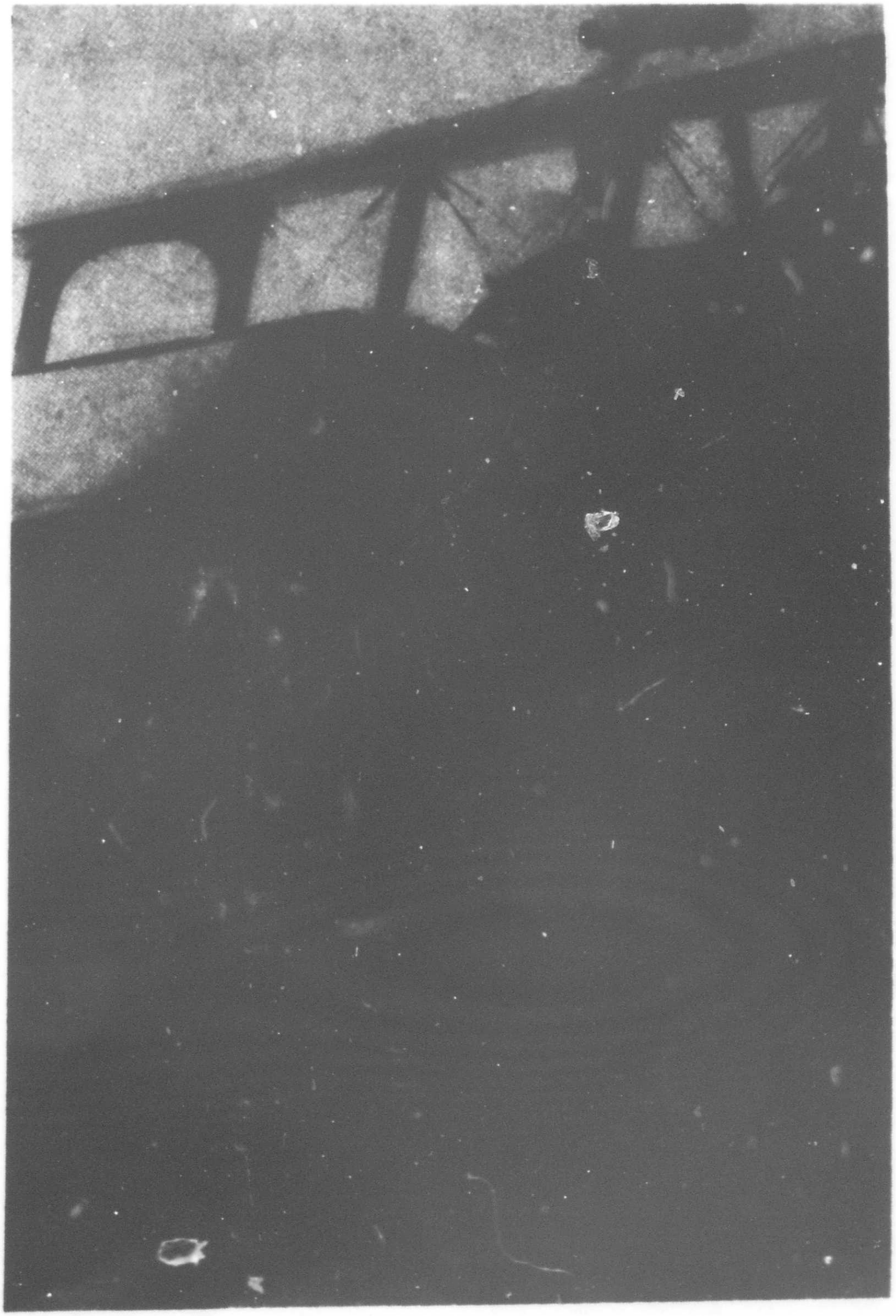

FIGURE 7 —

Research in 1921 produced this high altitude equipment designed for operation up to 40,000 feet.

in an airplane crash. But Major Lloyd E. Tefft came back to the Laboratory shortly thereafter to head the Department of Ophthalmology and Otology (now combined), while Captain Frederick H. Thorne would return eventually to the Department of Physiology as Major Schneider's successor.

Two months later, in November 1919, the Laboratory moved to a new location for the first time since its founding.[17] It had no great distance to travel—less than a mile across the highway on its southern boundary to Mitchel Field, outside the towns of Garden City and Hempstead. The War Department was winding up the last of its operations at Hazelhurst, before releasing the wartime base to local authorities for a private airport.[18]

Soon after the Laboratory departed, Hazelhurst was renamed Roosevelt Field, in honor of Quentin Roosevelt, former President Theodore Roosevelt's son, who had been shot down over France in 1918. (The Roosevelts had lived only eleven miles from Mineola, at Oyster Bay, where the old Rough Rider had died a few months after his son.) Roosevelt Field was to be the scene of many aviation exploits in the next decade, among them the solitary departure of Charles Lindbergh on his flight across the Atlantic to Paris in 1927.

Mitchel Field was now the Army's most active air base in the New York area. It was named for Major John Purroy Mitchel, who had resigned as mayor of America's largest city in 1917 to become a military pilot, and had been killed in an airplane accident the next year. Like Hazelhurst, it had been built in haste. The new quarters assigned to the Laboratory were almost a replica of the old ones. The prime advantage of the move was that it brought the institute of flight medicine once more into the midst of a busy center for military aviation.

In the spring of 1920, Congress passed the Army Reorganization Act.[19] It gave the Air Service a considerable degree of autonomy. In addition to its own medical department, the air arm now controlled its own research and development programs with the funds to support them, its own procurement and supply of aircraft and flight equipment, its own personnel management and training. In all of these functions it was unique among the combat elements of the Army, resembling more closely the Marine Corps in its status as a separate fighting force within the Navy.

One effect of the reorganization was a change of policy in the Air Service that allowed the Laboratory to engage civilians for the first time as research scientists, instructors, and technicians.[20] The professional staff now was reduced to 7 officers. The enlisted technicians—nearly all of them college students with some training in the biological sciences—now were gone. To balance some of these losses, the Laboratory created positions for 8 professional and 6 technical civilians. Together with 3 civilian clerks and 2 janitors, they brought the total complement of the Laboratory back up to 26.

Two of the civilian scientists were department heads. Major Edward C. Schneider secured his release from active duty, but stayed on as director of the Department of Physiology, which had the largest number of civilian assistants. Miss Barbara Valette Deyo filled the vacancy left by Major Knight Dunlap as head of the Department of Psychology. (See Appendix V.)

Under this new alignment of officers and civilians, in 1920 the Laboratory graduated eleven more flight surgeons, apparently in two classes.[21] The course had now been lengthened to three months. In the first of the longer classes, the honor graduate was the commander himself, Major Louis H. Bauer. He thereby established a precedent that a medical officer serving on the faculty—and particularly the commander—should be a flight surgeon. The honor graduate in the second class was Captain Eugen G. Reinartz, who would return as commander with the rank of brigadier general in World War II.

Also among the graduates was Major Edward L. Napier. Three years later, he was to be the second flight surgeon killed in an airplane accident.[22]

Again two classes were scheduled for 1921. The first had been in session only a week when, on Saturday night, March 19, the Laboratory burned to the ground.[23] All of its administrative files were destroyed. So were the original findings of its research since 1917, the medical library, teaching documents and records, and most of its experimental equipment. The Laboratory would have to be rebuilt from its foundation and fitted out all over again. Much of the material which it had lost could never be replaced.

Because of this catastrophe, when Army historians almost a quarter of a century later tried to recreate the early years of the Laboratory, they found hardly any mention of it in official

archives. Even at the War Department, in the confusion after the Armistice, most of the records bearing on the Laboratory and its conception had been cleared away.[24] The information had to be compiled and pieced together bit by bit from the recollections of participants like Wilmer and Isaac Jones, written after the event, and from passing references in contemporary journals and Air Service manuals and bulletins.

Fortunately, these sources gave a reasonably full and precise account of the experiments performed by the Laboratory in its first four years, and of the results obtained. But the original data on which the results were based had been consumed by the fire. So the experiments had to be repeated, in order to validate the findings.

For one group at Mitchel Field, the fire promised to provide a pleasant holiday.[25] They were the students in the class which had just begun. Like students everywhere when the school burns down, they assumed that the course would be suspended until the Laboratory could be rebuilt. They were mistaken. Major Bauer spent Sunday looking for emergency class rooms and equipment. On Monday morning the classes resumed in the staff officers' quarters, and clinical visits were hastily arranged at hospitals around New York City.

Only the demonstrations in the low-pressure chamber had to be canceled. The steel chamber had survived the fire, but most of its auxiliary equipment had been badly damaged, and so would have to be repaired or replaced. The work of reconstruction went forward without delay. In another month or so, the Laboratory was back in a new building with new equipment hardly distinguishable from the old. Only the intellectual contents took longer to reassemble.

By the end of 1921, another fifteen flight surgeons had been graduated.[26] They brought the total number trained by the Laboratory under the new program to 44, an even dozen more than Isaac Jones had selected in 1918.

Among the graduates were Captain Fabian L. Pratt, another future commander, and Captain Raymond F. Longacre, who stayed on as Major Bauer's deputy and head of Neuropsychiatry. Later on, he would serve too as a medical director of the Civil Aeronautics Administration.

Also a graduate was Captain David W. Bedinger.[27] He was to be the third flight surgeon killed in an airplane accident, in 1924.

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Chapter 5

WIDENING HORIZONS

During the early nineteen-twenties, while the Medical Research Laboratory was at Mitchel Field, a peculiar process gradually became apparent. The size and physical resources of the Laboratory continued to shrink, almost but not quite to the vanishing point. Yet, slowly and without any particular fanfare, its influence began to spread.

This paradox was the result of a larger phenomenon, hardly noticed at the time. Worldwide interest in aviation was increasing. Air shows with the atmosphere of county fairs wandered around the countryside, attracting crowds of spectators and participants. International air races and exhibitions grew common. Pilots from Europe and America competed for the honor of setting new records in transcontinental, transoceanic, and round-the-world flights. Their colorful journeys were followed by the press. The first public air services, carrying mail and then passengers, were established.

By insensible degrees, the realization came that, if aviation was to mature into a normal mode of transportation, medical standards were needed to regulate its safety for the protection of both the pilots and the passengers. Flying as a daredevil feat was all very well for sportsmen; but for the everyday traveler flying would have to be made reasonably reliable. The only source of knowledge about the physiological effects of flight still was the Medical Research Laboratory. And so, despite its minute dimensions and its obscurity, the Laboratory became a doctrinal center for scientific information in its field.

The means by which it began to disseminate its knowledge was not research, for which it had been founded. Instead, that instrument was the teaching program, added more or less as an afterthought. Creative research called for a number of people with

original (and sometimes divergent) views, working together and interacting one upon another. To be fully productive, research needed access to new equipment and to a continuing flow of funds. But teaching could be carried on effectively by a small staff of talented specialists, who understood and could communicate the principles which had been discovered already, using the same apparatus with which the discoveries had been made. This was exactly the situation in which the Laboratory now found itself.

For the next few years, the growth of aviation was not to be in the direction of more advanced vehicles, capable of climbing to higher altitudes at greater speeds and performing more involved manoeuvres. Rather, it was to lie in wider use of the vehicles developed during the War, arousing more general interest in the practical possibilities of human flight. For that kind of growth, the knowledge already accumulated by the Laboratory would suffice.

The extension of the Laboratory's influence was in no way spectacular. It consisted of a slow advance, by steps little noticed at the time, into new areas outside the circumference of the Air Service, where the study of the aviator's constitutional reactions had begun. The initial step was taken in the spring of 1922, when for the first time the Navy sent a group of medical officers to take the course in flight medicine at the Laboratory.[1]

The five Navy lieutenants in that group—together with five more Army doctors—were graduated as flight surgeons on April 29. One of them was Lieutenant Victor S. Armstrong. A year later, he would become the first Chief of the Division of Aviation Medicine in the Navy's Bureau of Medicine and Surgery.[2] In that position, he was to build a corps of specially trained physicians for the care of Naval aviators, modeled on the one that Colonel Lyster had developed for the Army.

In the same class, incidentally, was Lieutenant Colonel William R. Davis, who had just been appointed to succeed Colonel Truby as Chief Surgeon of the Air Service. From now on, every head of the air arm's medical department would be a flight surgeon trained in the course inaugurated by the Laboratory.

The broadening of membership in the class to include physicians of the Navy as well as the Army brought to a climax a movement

which had been under way for some while. Since the teaching program had started up again, three years before, the Air Service had given more and more attention to the Laboratory's educational function, and less to its activities in research. Increasingly, the institute at Mitchel Field was considered primarily a training academy for flight surgeons, with research as a secondary mission whose main purpose was to improve the content of the curriculum.[3]

A year earlier, in February 1921, the War Department had implicitly recognized the preeminence of the educational function by granting it the semi-independent status of a "special service school." The practical effect of this order was to exempt the Laboratory from control by the Army's corps area commanders. In matters of routine military discipline, personnel administration, or the assignment of buildings and quarters, the Laboratory was responsible to the commanding officer of Mitchel Field. But its actual operation was directly under the Chief of the Air Service in Washington.

On November 8, 1922, this gradual transformation of the Medical Research Laboratory into a teaching academy was made final and complete. The name by which it had been known officially since its inception in 1918 was abandoned, and it became the School of Aviation Medicine. Its commander, Major Bauer, ceased to be the Officer in Charge. From now on, he was called the Commandant, a title reserved for the heads of training institutions. The original scope of its activities—comprising medical research and practice as well as education—was unchanged. Only the emphasis was altered.

The first class of flight surgeons taught by the School under its new name was then in session. Graduated on December 16, 1922, it was the largest class so far, with nineteen medical officers in all, of whom eleven more were from the Navy.[4]

The Army group included the next two commanders of the School after Major Bauer: Major Francis H. Poole and Major Benjamin B. Warriner. Major Poole was to return only two years later to head the Department of Neuropsychiatry.

Among the Navy surgeons, no less than three would follow Lieutenant Armstrong as chiefs of Aviation Medicine in the Bureau of Medicine and Surgery. They were Lieutenant Robert P. Henderson, Lieutenant John R. Poppen, and Lieutenant John C. Adams,

who would rise to the rank of Rear Admiral in World War II. In fact, every flight surgeon who was to hold this key position in Naval aviation for at least the next three decades would be a graduate of the Army School of Aviation Medicine.

The influence of the School on the worldwide practice of its specialty took an even longer step afield in 1923—although again the implications of that step were not yet evident. When the second class of the year assembled in September, it was found to consist of just four students. One of them, however, was the most exotic figure seen at the School up to that moment. He was Lieutenant Mário Pontes de Miranda, a young medical officer of the Brazilian Navy.[5]

It was by no means exceptional for representatives of the armed forces of other countries, with which the United States was friendly, to enroll in American military schools, either as serious students or as observers. Foreign officers had attended the Academy at West Point, the Command and Staff School at Fort Leavenworth, Kansas, and some of the wartime flying schools. They had only to apply through their embassies or legations to the Secretary of War, and normally were accepted as a point of diplomatic courtesy if they had a good working knowledge of the English language.

Doctor Pontes de Miranda, from the coastal state of Alagoas, had just turned 29. He had studied medicine in Rio de Janeiro, receiving his degree in 1917, had taken a competitive examination for the Navy Medical Service, had passed it, and had been commissioned a year later. After routine Navy assignments, he had somehow heard of the School at Mitchel Field, had applied for it, and had been accepted.

Enrolled by the staff with only mild surprise, Doctor Pontes de Miranda attended the course and was duly graduated on December 16, 1923. Thus he became the first fully trained and qualified flight surgeon of a nation other than the United States. The next student medical officer from abroad (Captain Armando de la Torre of the Cuban Army) would not arrive until 1927; and physicians in strange uniforms, conversing in unfamiliar tongues, were to become habitués of classes at the School only after the close of World War II.

By that time, Doctor Pontes de Miranda would no longer be accessible to explain how this trend had started. In 1931, still pursuing his taste for unusual medical studies, he would go on to

Mount Sinai Hospital in New York City and enroll in a course dealing with diseases brought on by nutrition. He would then return to practice in Brazil. There, in April 1937, at the early age of 42, Doctor Pontes de Miranda himself would die of an "insidious disease" for which he had been taught no effective therapy.

While the School was reaching out into new teaching channels, its funds were contracting. During these early years, it had no comprehensive budget.[6] Its military people were paid from Army funds for which the Field was accountable. Not until the first non-uniformed staff members and assistants were employed in 1920 was the School allotted its own money with which to meet the civilian pay roll.

Similarly, until 1922 its equipment was provided and maintained by the Air Service Medical Department. Only then was the School made responsible for acquiring and servicing the instruments with which its work was done—probably because they were now under the care of civilian technicians. In 1922, the non-military pay roll was just under $27,000, while equipment purchases and maintenance came to slightly more than $17,710. The total spent from these two funds was $44,710.

In 1923, civilian salaries went up a bit, to $30,170. But expenditures for equipment went down a bit more, to $14,300. So the total for the two funds dropped slightly, to $44,470. Thereafter, both funds declined. By 1925, civilian pay had fallen off to $21,232, while a mere $2,473 was spent for equipment, bringing the total to $23,705.

The reduction in funds allocated to the School was reflected in the size of its operating staff.[7] The professional civilians one by one departed, until only two were left in 1925, from the eight who had joined the staff in 1920. Technical civilians likewise dropped away, leaving two of the original six. Moreover, one officer was lost. By 1925, the total complement of the School was down to eighteen. But for a small increase in the enlisted help, it would have been less.

The officer who was lost in 1925 was the commander himself.[8] In August of that year, Major Louis H. Bauer was selected to attend the Army War College in Washington. He departed in September, leaving his assistant, Major Francis H. Poole, in charge.

Again, as in 1918, when Colonel Wilmer had sailed for France, the School was to have no resident head for the next few months.

On the last day of December, the one staff member remaining from the first conception of the Medical Research Laboratory terminated his eight-year association with the School.[9] Dr. Edward C. Schneider resigned as head of the Department of Physiology, to accept a position as Professor of Biology at Wesleyan University in Connecticut. He was to hold that chair for nineteen years, until his retirement in 1944 at the age of 70, and then would live for another decade, reflecting on the vast world above the ground which he had helped to explore.

His departure brought to an end the only active research program still carried on by the School. Of this program the Commander wrote in his annual report for 1926: "There is . . . reason to believe . . . that the facts of physiology . . . which have been so extensively investigated during the past six years are far in advance of the immediate requirements [for the Air Service]." Doctor Bauer recommended that the Department of Physiology should be discontinued for the immediate future, and that the School should concentrate on "problems . . . more directly connected with the selection of the flyer."

His recommendation was in fact followed.[10] Physiology was absorbed into the Department of Aviation Medicine. For the next fifteen years, until World War II, the School was to manage with just four departments. Besides Aviation Medicine, they were Neuropsychiatry, Ophthalmology-Otology, and Psychology. These were indeed the areas then considered most vital in the selection of flyers.

Doctor Bauer was greatly indebted to the outstanding work that Professor Schneider and his assistants had performed. In January 1926, Bauer published his book, *Aviation Medicine*, the first comprehensive text on the subject for general use.[11] Like the *Manual* that Wilmer had edited, it was based almost entirely on research performed by the Laboratory and the School of Aviation Medicine.

But whereas the *Manual* had been mainly a guide to the research itself, showing its applications in the flight surgeon's practice, *Aviation Medicine* was a thorough distillation of the teaching

course given at the School. Its three sections were devoted to the selection of the flyer, to the physiology of aviation including the classification of the flyer, and to the care and maintenance of the flyer's health and fitness. Forms and instructions for the various examinations then given were included in a supplement.

In the Preface, Bauer acknowledged the contributions made by members of the staff to specific chapters. But his appreciation of the help given by Professor Schneider was inclusive. Schneider, he wrote, "has given many suggestions and criticisms, and . . . has reviewed nearly every chapter. The section of physiology is based to a large extent on his work. In fact, nothing could be written on the physiology of altitude without quoting him largely." The book was dedicated to Schneider, "a pioneer in aviation physiology . . . as a token of friendship and esteem."

Indeed, Bauer's text could be considered a final testimony to the importance of the basic studies carried out by the Medical Research Laboratory, and to the fundamental value of the work done by Professor Schneider, the last of its founders to leave the School.

In April 1926, while Major Bauer was still at the War College, the Acting Commander, Major Francis H. Poole, was called to Washington.[12] The Chief Surgeon of the Air Service, Lieutenant Colonel William R. Davis, was considering another change in the status and location of the School.

It was not the first time in recent years that this idea had come up. The same suggestion had been made in 1921, after the fire at Mitchel Field. Major Bauer had opposed it, pointing out that no other Army air field could offer so many professional advantages in the proximity of a fine medical library at the New York Academy of Medicine and the many major clinical facilities in the New York metropolitan area. Major Bauer's view had prevailed then. But now the situation had changed.

In 1922, the Air Service had concentrated all of its flight training at two fields on the edge of San Antonio, Texas. Primary training was given at Brooks Field, near the southeast corner of the city. Advanced training was given at Kelly Field, near the southwest corner, seven miles away. These had now become the two most active flying centers in the Army. Mitchel Field was

relatively quiet, maintained as a tactical base for the potential defense of New York City in the improbable event of another war.

Out of recent pilot-training classes at Brooks Field, as few as 17 per cent of the cadets had successfully completed the course and received their commissions. As many as 53 per cent had been eliminated for "lack of inherent flying ability," while 12 per cent or more had been unable to pass the academic subjects. Of the rest, a number had turned out to have physical defects overlooked by the doctors who had first examined them.

Since all of these problems now were the responsibility of the flight surgeons trained by the School, the War Department had concluded that the teaching course must be deficient in some respect. The suspicion was that it had become too theoretical—that the students and instructors at Mineola were too remote from the practical difficulties involved in the selection and care of flying cadets. If that was so, the obvious solution would be to place the School of Aviation Medicine once more at the same field where the pilots were trained. In other words, the School would have to move again—this time to Texas.

So Colonel Davis and Major Poole made a trip to San Antonio and looked the city over as a professional environment. While it certainly was not a clinical center comparable to New York—its population then was around 200,000—San Antonio had the usual resources for medical treatment found in a city of its size. Besides, the Army Hospital at Fort Sam Houston was an outstanding military medical facility. On their return, toward the end of April, they recommended the transfer of the School to Brooks Field.

Orders directing the move were issued by the Secretary of War in the middle of June. The staff packed all of its equipment and supplies except the low-pressure chamber—for which it no longer saw any need—into 552 boxes weighing more than 40 tons, and loaded them into freight cars on June 26. By the end of the month, the School was gone from Mineola, its home since its founding almost nine years before.

To Texas with it went a little band of ten persons. They included three medical officers: the Acting Commandant and head of Neuropsychiatry, Major Poole; Captain Neely C. Mashburn, a medical psychologist; and Captain Frederick H. Thorne, newly

appointed head of Ophthalmology-Otology. One was the Executive Officer, Captain William J. Freebourn. Two were civilians, Mr. Asa F. Constable, a laboratory assistant, and his wife, Helen Hambler Constable, a clerk. The other four were enlisted technicians. Only these were left of a complement which had once amounted to more than a hundred.

Doctor Bauer was not among them.[13] He had finished his term at the War College and had just been reassigned as a medical officer at Fort Benning, Georgia. Even if the Army had chosen to leave him in charge of the same organization which he had now commanded for almost seven years, it is doubtful that Bauer would have cared to accompany what remained of the School to Texas. Both by association and by temperament, Louis Bauer was an Easterner, with a taste for the wider circles of his profession that were found along the Atlantic Seaboard.

He had taken a liking to the Long Island countryside. For the last thirty-four years of his long and imposing career, Bauer was to live in Rockville Centre, a few miles south of Mineola. For twenty-five of those years, he would be a practicing cardiologist, with his office in Hempstead.

Besides, a new possibility had opened up for Major Bauer. Congress had just passed the Air Commerce Act, establishing an Aeronautics Branch in the Department of Commerce. Among its other provisions, the Government was authorized for the first time to license all civilian pilots on the basis of proficiency ratings and periodic physical examinations. The Assistant Secretary of Commerce for Aeronautics, William P. McCracken, Jr., was looking for a medical director to develop and administer the physical standards.

Naturally, he consulted with Louis Bauer, whose book had appeared only a few months before, and who was now the ranking authority on aviation medicine. The outcome of their conversation was that, in November 1926, Doctor Bauer resigned his commission in the Army and accepted an appointment as the first Medical Director of what was afterwards to become the Civil Aeronautics Administration and in time the Federal Aviation Agency.

Although he was no longer directly associated with the School, in his new position Bauer was to stake out a vast new field of influence for its teaching. Not only would the Federal Aviation Agency itself need medical examiners and flight surgeons to put the new regulations in effect. So too would all the larger airlines in the nation—and eventually in the world—to comply with the provisions of the Act. There still was only one training academy for these physicians. It was the School of Aviation Medicine, now removed to Texas.

As it turned out, all six medical directors of the Agency through World War II and for a decade afterward were to be flight surgeons graduated by the School. In Doctor Bauer's steps would follow Dr. Harold J. Cooper, Dr. Raymond F. Longacre (who had been also the Assistant Commander on Major Bauer's staff), Dr. Roy E. Whitehead, Dr. Eldridge S. Adams, and Dr. William R. Stovall.

Not only that: in February 1927, when Doctor Bauer announced the names of 39 physicians around the country who had been appointed aviation medical examiners for the Department of Commerce, a third of them were flight surgeons recently trained by the School, while half a dozen more were to take the course in a Reserve status over the next few years. One of these was Dr. Ralph N. Greene of Jacksonville, Florida, the first medical officer qualified by the Army as a pilot back in 1916.

The medical examiner in New York City was Dr. Conrad Berens, Jr., not a rated flight surgeon but a member of the original staff of the Medical Research Laboratory. Most of the others were among the first medical examiners for the Signal Corps, appointed by Isaac Jones in 1917.

Over the years ahead, many such early specialists in the human problems of flying would become medical directors or consultants for the airlines. Their circle would be relatively small and very select before World War II, as it was to be likewise for the flight surgeons of the Army and the Navy. But it would be growing. And all of these specialists, military and civilian alike, would look to the School of Aviation Medicine as the source of their arcane knowledge.

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Chapter 6

AT HOME IN TEXAS

By coincidence, Brooks Field was almost exactly the same age as the School of Aviation Medicine.[1] In the fall of 1917, after Kelly Field had been in operation for several months, the Army had asked the San Antonio Chamber of Commerce to recommend a site for another training base in the same general area. The new field was wanted to train flight instructors.

Among the specifications were that the location should be on flat ground, suitable as a platform from which to take off and land airplanes, with soil porous enough so that it would not dissolve into a sticky bog after rains. Another qualification was that it should be within reach of the city's varied recreation facilities.

The flat side of San Antonio was to the south and east. The Chamber picked a tract of 873 acres next to the village of Berg's Mill, six miles out of town on the road to Corpus Christi. The brush and mesquite were so thick that the selection committee had to build a tower from which the Army officers could view the site.

Nevertheless, the Army liked it. They accepted a lease from Chamber President Franz Groos on December 15, 1917. Meanwhile, the city already had begun to clear the land and extend utilities toward it. An Army construction group arrived at the end of January 1918 to put up hangars and buildings. Major Henry Conger Pratt (later a brigadier general) took command on February 16. The first squadrons moved in during the next four weeks, and the first flight took off on March 28.

The base had been known originally as Gosport Field, for a system of flight instruction devised by the Royal Flying Corps at Gosport, England, with voice communication by a speaking tube between the instructor and the student pilot. The system was

tested at the field in Texas, and was adopted by the War Department in October 1918 for all Army training schools in the United States.

But in the spring of 1918 the field had been renamed—this time in memory of a San Antonio native, 22-year-old Cadet Sidney Johnson Brooks, who had crashed upon his return to Kelly Field from the final qualifying flight for his commission and his pilot's wings on November 13, 1917.

Young Brooks was the son of a prominent San Antonio attorney, Judge Sidney J. Brooks, and Mrs. Brooks. After grammar school and high school, he had enrolled in the University of Texas at Austin. Midway through his second year, in January 1914, he had left the University because of poor health. Back at home in San Antonio again, he had worked for a while as a reporter for an afternoon newspaper, *The Light*.

In 1916, Brooks had been well enough to return to his studies at the University. This time he had stayed on until the entry of the United States into the European War the next spring. He had then enlisted in the Army. After ground instruction at Camp Funston, Alabama, and later at the aviation school in Austin, he had reported to Kelly Field for flight training. He had been there almost four months and had marked up twenty hours in the air on the day of his fatal solo.

The flight was across country to the town of Hondo, thirty miles away, and back to Kelly. As the formation was on its approach to the field, at a height of about 2,000 feet, Brooks's plane was seen to nose over in a moderately steep dive. It flew straight into the ground. Eye witnesses were of the opinion that Brooks had lost consciousness as he was getting ready to land. He was said to have received some immunization shots in the morning, not long before the flight.

Whatever the exact circumstances had been, it was to prevent just such needless accidents that the Medical Research Laboratory had been created at about the same time. After his death, Sidney Brooks had been awarded his wings and his commission as a second lieutenant.

At the end of the War, the instructor school had been closed at Brooks Field. In May 1919, the base had been converted to a lighter-than-air training school for dirigible and balloon pilots. In the middle of the field, facing the half-semicircle around which the hangars were arranged, an enormous shed 465 feet long and 125 feet wide was built in 1921 to house the big hydrogen-filled air ships.

Specifically, it was intended for the dirigible *Roma*, which the War Department had bought from the Italian Government at a cost of something over a million dollars. In crated sections, the ship was taken to Langley Field, Virginia, for assembly and testing. There, in a test flight on February 21, 1922, the *Roma* struck a high-tension wire, exploded, and burned, killing 34 men, all but three or four of its crew.

Later in the spring of the same year, the semi-rigid air ship C-2 was sheltered briefly in the Big Hangar at Brooks, during a flight across the country. As it was brought out to continue on its way, a cross wind caught the bag and slammed it into the corner of the shed. Like the *Roma*, it exploded and burned. Still later, a companion ship, the C-5, was wrecked on a takeoff from Brooks.

As a result of these disasters, lighter-than-air operations were suspended at the Field in June of 1922. Shortly thereafter, Brooks became the Army center for primary flight training. Over the next few years, even though the number of cadets eliminated for deficiencies of one kind or another was high, some of the most renowned figures in military and civil aviation took their first flying lessons at Brooks. They included Charles Augustus Lindbergh, Frank M. Hawks, Orville A. Anderson, and a dozen or more ranking air commanders of World War II.

On July 2, 1926, while the School of Aviation Medicine was traveling toward Texas from Long Island, the American air arm was reorganized once more.[2] By Act of Congress, the Army Air Service was transformed into the Army Air Corps. Thus, from an adjunct to the ground forces, it was raised to the status of a fighting element in its own right, on a level with the Infantry, the Cavalry, or the Coast Artillery. An Assistant Secretary of War was created to watch over its welfare It was encouraged to expand toward the strength which had been authorized five years earlier and so far—because funds were lacking—had never been attained.

The immediate effect of this change on the School of Aviation Medicine was to remove that institution from its academic isolation, and to install it as an integral part of the flight training system. When the Air Corps Training Center was activated in San Antonio on August 16, under Brigadier General Frank P. Lahm, it was made up of three components. They were the Primary Flying School at Brooks, the Advanced Flying School at Kelly, and the School of Aviation Medicine, also at Brooks. No longer was the School answerable directly to Washington. It received its guidance from General Lahm.

By then, the School was settled in its first home at Brooks. The structure was an imposing one, if not entirely suitable for a medical facility. It was the Big Hangar, built to house the *Roma*. Set apart from the other buildings on the base, it had stood empty for the past four years, since the lighter-than-air unit had left. In this cavernous shelter, amids the buzzing and popping of airplane engines taking off or landing on the barren sod around it, the first class of flight surgeons to be trained in Texas assembled on September 5.

But teaching was no longer the sole nor even the prime preoccupation of the faculty. The School was now responsible for all physical examinations to determine fitness for flying—a task once left to medical examiners. A member of the staff was assigned to the flight line whenever student flyers were in the air. Although the Station Hospital and the School were separate, staff members took their turn on the duty roster as the Post Medical Officer of the Day. They treated patients referred to them by the Hospital for conditions peculiarly related to flying.

The professional staff now consisted of the acting commander, Major Poole, and his four department heads, Major Edward C. Greene, Captain Neely C. Mashburn, Captain Robert K. Simpson, and Captain Frederick H. Thorne. All were flight surgeons. (See Appendix VI.) Their official duties were nearly indistinguishable from those of the two flight surgeons assigned to the Flying School at Brooks, except that Captain Charles V. Hart and Captain Alexander Mileau were pilots as well.

In effect, the five medical officers on the faculty were practicing physicians first, and only secondarily medical educators. Their job was to do whatever needed to be done so that more candidates

FIGURE 8 —

This building was the second home of the School of Aviation Medicine after it was transferred to Brooks Field, Texas in 1926.

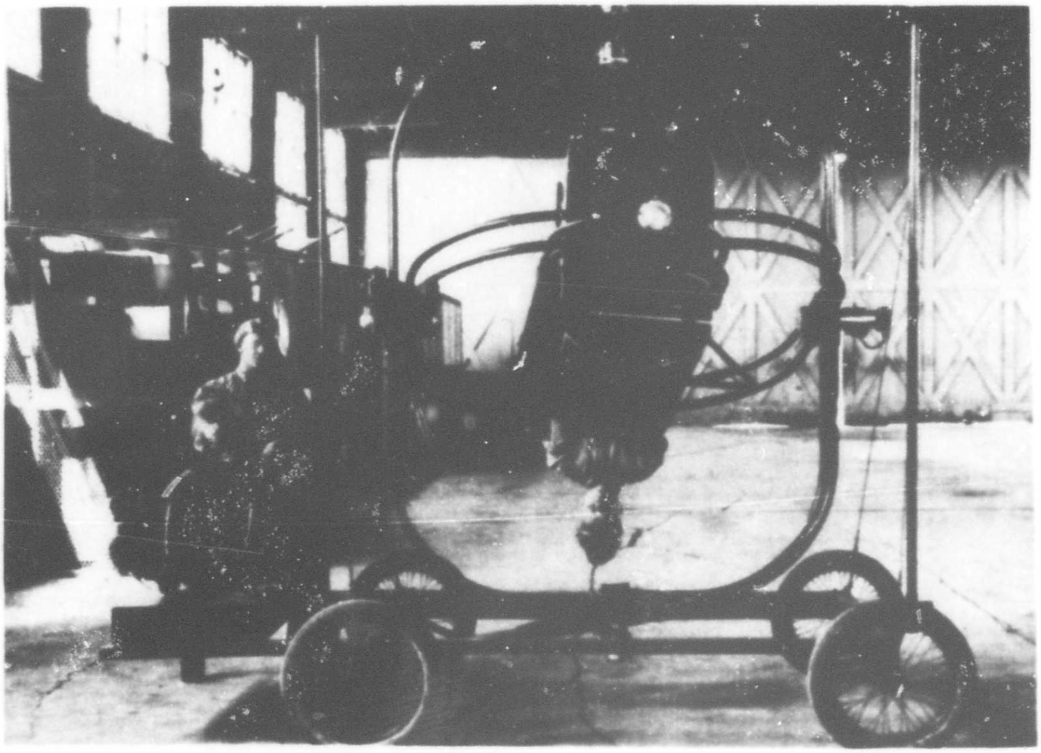

FIGURE 9 —

The Ruggle's Orientator used to orientate a pilot in the effects brought about by stunt flying proved to be of little value.

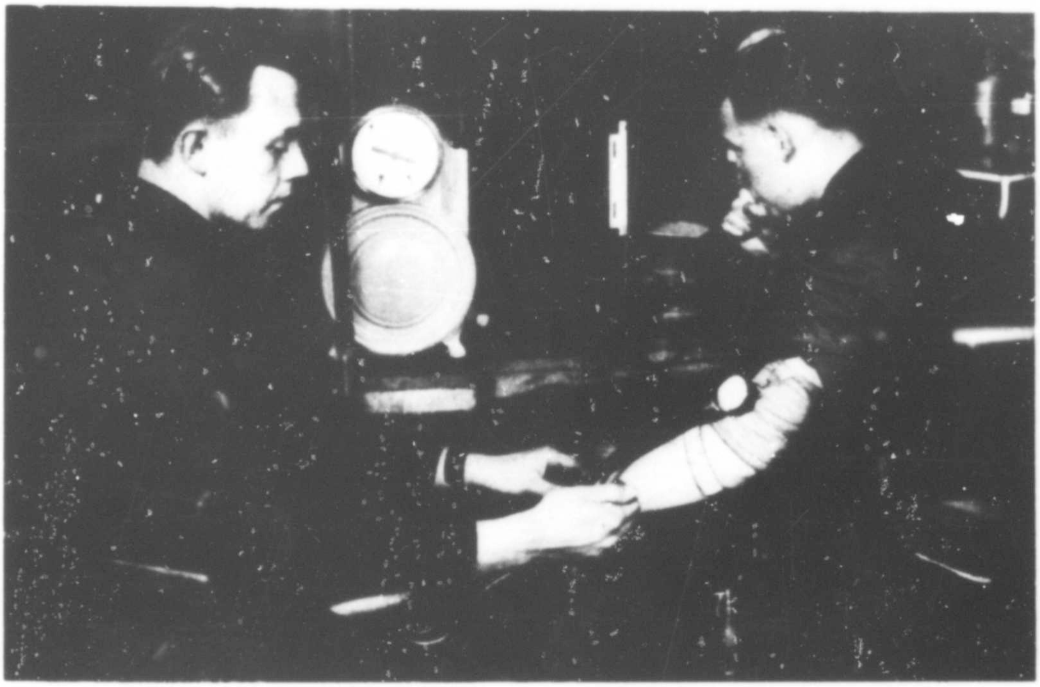

FIGURE 10—

In early studies at the School of Aviation Medicine a pilot has his blood pressure and pulse checked while in a hypoxic state.

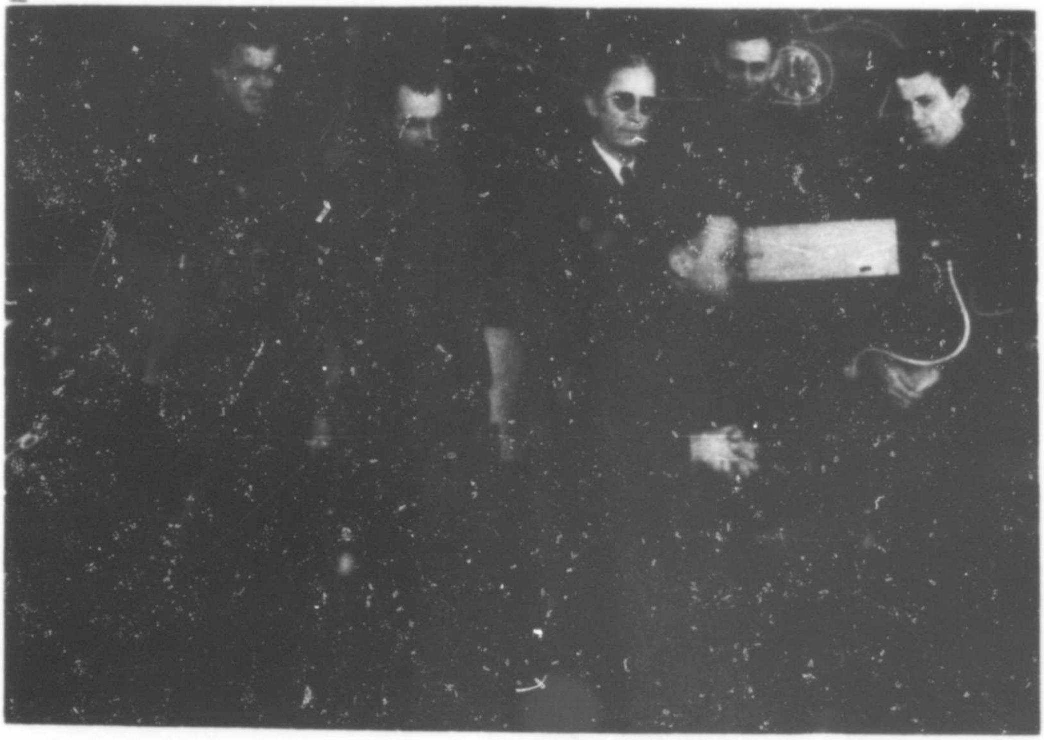

FIGURE 11—

The "Ocker box" an early training aid used in teaching instrument flying.

for flight training would be chosen who were mentally and physically capable of completing the course. In whatever time they had left, they could—if they chose—conduct research, but on their own initiative. They had left the ivory tower of thought, and had rejoined the medical community.

Nothing could have been farther from the idea of the School held by Lyster in 1917 or by Louis Bauer in 1925. Lyster had conceived it as a research institute from which authoritative solutions to the flyer's medical problems would issue. Bauer had viewed it as an academy where the techniques of flight medicine would be taught. Both had seen it as a small and highly specialized offshoot from the main body of medicine. For that reason, they had felt that it should cultivate a close affiliation with the vast pool of therapeutic knowledge and resources in the East.

Aviation medicine was indeed an unusual specialty in several ways. For one, it was defined not by a single area, function, or condition of the human organism, as were nearly all the older specialties, but instead by the exceptional environment in which the organism was expected to operate: namely, the atmosphere above the Earth. As a consequence, aviation medicine embraced, or could embrace, elements of every other specialty. In the range of his interests, the flight surgeon had a use for the versatility that distinguished the family doctor.

In another respect, aviation medicine had been set apart from the broad field of practice as a whole. Up to now, its development had occurred almost entirely within the military services, and particularly within the Army aviation branch, where the great majority of people under its care still were found. Military surgeons in the past had made notable contributions to the understanding and treatment of disease. For example, the Army had been largely responsible for the discovery of methods to control such infections as yellow fever, typhus, and malaria, the Navy for the prevention of scurvy. But these were among the common ailments of mankind, for which the causes and remedies were studied by all doctors. The maladies associated with flying, on the contrary, so far were little known and rarely encountered except among military aviators.

Research in aviation medicine had concentrated heavily on the effects of reduced oxygen and pressure at increasing altitudes.

As Bauer had written a few months earlier, on the suggested dissolution of the Department of Physiology, research had now gone far beyond the capability of the wartime airplanes still in use by the Army to test or apply all of these laboratory findings. Mainly for that reason, much of the enthusiasm for high-altitude research had subsided for the present at the School of Aviation Medicine. On the other hand, the requirement for trained flight surgeons in flying organizations—although it was growing—still came to no more than about twenty-five each year, limiting the scope of the School's teaching effort.

What aviation medicine needed at this point in its development was not so much access to advanced clinical or research facilities in the East. Rather, the need was for a more intimate understanding with the flyer who was the subject of these studies—for an opportunity to win his confidence, trust, and regard. The ideal setting in which to pursue such a goal was an active air base, in surroundings hospitable to the military outlook and traditions.

From this viewpoint, Brooks Field was admirably situated. It was the Army post where the future pilot and air leader first met the flight surgeon, who was to exert so much influence over his eventual career and achievements. Relationships formed here would later ease the task of aviation medicine in watching over the flyer's health and fitness.

As for the surroundings, San Antonio had been an army center for some two centuries or more, from its founding as a garrison for the soldiers of Spain.[3] More than any other city in America, it had been a background for the lives and the campaigns of military people. In every war and border skirmish involving the six nations to which it had successively belonged—Spain, France, Mexico, Texas, the Confederacy and the United States—San Antonio had played a significant part. During frontier days, the Cavalry had protected its outlying settlements from marauding Indians, and sometimes had provided them with medical attention as well. For as long as the city had been there, San Antonio women had been marrying army men, bearing them children who would serve in the Army's next generation.

Since 1875, Fort Sam Houston had been the Army's prime administrative headquarters in the Southwest. The leisurely old post, occupying five square miles on the eastern side of the city,

was built around a shady quadrangle with ducks floating on a pool beside its gray stone clock tower. The spacious officers' club was a center for social activities in the area. The San Antonio Country Club, close by, shone with dress uniforms on every gala occasion. The Army Hospital was an attraction for retired officers and men. The Fort Sam Houston National Cemetery often was their final resting place.

The Army's first airplane had flown off the vast parade ground at Fort Sam in 1910, with Lieutentant Benjamin D. Foulois—later Chief of the Air Corps—at its controls. Even the rise of Kelly and Brooks Fields on the southern border of San Antonio had not diminished, but rather had enhanced, the prestige of Fort Sam Houston. Its own flight surgeon, Captain Levy S. Johnson, was assigned to the air division on the post.

So the School of Aviation Medicine was to find itself as much at home in San Antonio as it had been at Mineola. Indeed, it was more at home there, because it stood out as the only institution of its kind in that part of the world at that particular time. Its Army superiors were more aware of it than they had been when it was on Long Island, and were more interested in providing for its needs.

To give their interest tangible form, toward the close of 1926, after the School had done its best to get along in the drafty dirigible hangar for several months, they set aside funds to erect new accomodations for it. The handsome quarters that began to go up shortly afterwards were among the few permanent structures on the base, and the first ever occupied by the School. Two stories tall, they were built of hollow cement blocks covered with white stucco and topped by a roof of red tile in the prevailing Mediterranean style of that period in San Antonio. The building's thirteen rooms included offices, a lecture hall, a library, two clinical examination rooms, storage space, and a fabrication shop for mechanical devices and instruments, presided over by Mr. Constable.

By that time, Major Poole had been appointed Commandant on permanent orders. In May 1927, he rounded up his people and equipment and installed them in the new building. There they were to carry on their work, without any significant change in policy or methods, for the next four years.

The individual character of research in aviation medicine was evident in the two outstanding developments with which the School was associated during this period. They were the Ocker-Crane system of "blind flying" by instruments and the Complex Coördinator to predict flying ability in candidates for pilot training.

From the first experiments in air travel to considerable distances across country, unforeseen change in weather had been the worst enemy of the peacetime aviator.[5] In fog, heavy cloud cover, rain, or any other condition where he lost visual contact with the ground, even a veteran pilot found that his other senses, governing his awareness of equilibrium and direction, soon failed him. If he was able to maintain level flight at all, and could not get under or over the weather or find his way out of it, he would end by flying in circles until he ran out of fuel and crashed.

For the same reason, night flying was restricted to evenings when brilliant moonlight offered clear visibility, and to populous areas where lights on the ground could be used for guidance in finding the field and landing. Yet the growth of commercial air transport would be limited until schedules could be maintained after dark and in all but the worst kind of weather. Even military flight operations were hampered if they could be carried out only under ideal flying conditions.

Major William C. Ocker, an Air Corps pilot, had become interested in this problem as early as 1918, when the Army had given him a new instrument developed by Elmer A. Sperry—the turn indicator—and had asked him to test it. Using this instrument with the compass for directional control, Major Ocker had flown through fog over the mountains from Washington, D. C., to Ohio, carrying the Chief of the Air Service as a passenger. But Ocker had been convinced that the sense of balance was inherent in the pilot and could be sharpened only by experience and training.

In January 1926, a few months before the School of Aviation Medicine moved to San Antonio, Major Ocker had reported to the flight surgeon at Crissy Field in San Francisco for a routine physical examination. Captain David A. Myers, the flight surgeon (who was to become Chief Surgeon of the Air Corps), had given him an exhaustive test in the Barany Chair with his eyes covered. By revolving him in different directions at varying speeds, Doctor Myers had shown that without visual cues of any kind he could

not tell when or in what direction he was turning. The reason was that the otoliths in the semicircular canals of the ear, on which balance and the sense of direction mainly depended, obtained their information from changes in the rate and bearing of the acceleration, rather than from changes in the trend of the motion itself.

Ocker had left the office, and had returned presently with a turn-and-bank indicator, an improvement on Sperry's original instrument. Using only this indicator for visual orientation, he was able to correct the false impressions given by the responses from his otoliths. When the artificial horizon was added to the turn-and-bank indicator, the pilot had a complete representation of his attitude in the air, regardless of the weather. In effect, they gave him an imaginary view of the ground.

Beginning in the spring of 1927, the experiments of Major Ocker and Captain Myers were repeated at the School of Aviation Medicine, this time on a systematic basis, by Captain Frederick H. Thorne, director of Ophthalmology-Otology, and Captain Robert K. Simpson, director of Aviation Medicine.[6] Their studies confirmed and strengthened those of Doctor Myers. Largely on their recommendation, the Air Corps Training Center invited Major Ocker to develop a course in instrument flying for the Advanced School at Kelly Field. The system was adopted by the Air Corps in May 1934.

The Complex Coördinator was an outgrowth of another research project by Doctor Thorne.[7] Before the School of Aviation Medicine had left Mitchel Field, the staff had recognized that the large percentage of cadets eliminated from flight training reflected something more than physical unfitness. The student pilot might be constitutionally sound and in perfect physical condition, and still have emotional problems that interfered with his performance. Or he might simply lack the mechanical aptitude and the nerve reflexes needed to fly an airplane.

Psychiatric personality tests had done away with many of the failures caused by emotional disturbances. There had remained the need for a reliable means of measuring aptitude. In the search for such a test, Captain Thorne had devised the Reaction Time recorder. Mounted on a table, it consisted of two telegraph keys, an electric buzzer, and a panel displaying red and green lights.

When one of the lights went on or the buzzer sounded, the subject answered by pressing either the right or the left key, following instructions given to him in advance. His errors were recorded and the time required for each response was measured in hundredths of a second. The composite score reflected both the accuracy and the speed of his reactions. During the five years that the test was used, 71 per cent of the students with the highest scores were graduated, while only 39 per cent of those in the lowest group were qualified as pilots.

But there were also some anomalies. For example, in the next four categories above the lowest, smaller ratios of graduates were found than at the bottom, ranging from 23 per cent to 28 per cent, and not in the order of their scores. Still, the Reaction Time test gave a rough indication of the probability that the student might become a pilot.

Meanwhile, in 1926, Dr. L. J. O'Rourke, Director of Personnel Research for the Civil Service Commission, designed the first Complex Coördinator for the School. Built by the Bureau of Standards at a cost of $900, it was an armchair mounted on a wooden platform before a simulated airplane control column and rudder pedals, facing a panel with a buzzer and a series of red, white, and green lights. Instead of pressing a telegraph key, the student answered these signals by manipulating the controls in one of the several manoeuvres which he could have performed in an airplane.

The test was an advance over Thorne's because of the greater variety and realism of the responses. During the four years that it was in use, from 1927 to 1931, it gave a better correlation than the simple reaction-time test between the scores attained and the actual proportions of the students graduated. The ratios varied from 74 per cent for the highest scores down to 14 per cent for the lowest, fairly well graduated in between.

But this apparatus had its drawbacks too. It was difficult to operate and complicated to score. From the fact that 26 per cent of the students in the highest group did not succeed in actual training, while 14 per cent of those in the lowest group did, it was obvious to Captain Neely C. Mashburn—who carried on this work in the Department of Psychology—that some significant factor related to flying ability was missing from the tests.[8]

On the other hand, it was equally obvious to Doctor Mashburn that the tests had considerable value in estimating the probability that the student would be successful. He thought that more accurate ratings might be given by an automatic test machine, calling for a predetermined series of decisions by the subject, each one presenting itself only when the previous one had been made correctly.[9] Too, when errors were eliminated except in counting the time taken to complete the test, the scores might yield a more valid comparison between subjects.

So Captain Mashburn applied himself to the design and construction of an automatic serial-action complex coördinator.[10] The first experimental version was finished and ready for testing in May 1931, when Neely Mashburn was ordered to the Philippines for a tour of duty overseas. On his return to San Antonio, three years later, he would find the School of Aviation Medicine gone from Brooks Field and installed in more elaborate quarters twenty miles away, at a new base known as Randolph Field.

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Chapter 7

THE MUTED YEARS

Randolph Field embodied a new concept in the design of Air Corps bases. Built without haste, at a time when another war appeared to be the least likely of prospects, it had a look of breadth and permanence.

The site was on a plateau fifteen miles northeast of Fort Sam Houston.[1] There, in August 1928, through a company formed for that purpose, the city of San Antonio had bought 3.62 square miles of farm land at a cost of more than half a million dollars, and had presented it to the United States Government. The Air Corps had started laying out the field a month later. It was planned as a home for the Training Center, of which the School of Aviation Medicine was a part.

The base facilities were to be enclosed in a rectangle facing the tracks of the Southern Pacific Railroad just beyond the gate at its north end. Down both the long sides of the rectangle were to be shops and hangars. The inner area was arranged in a wheel-shaped pattern of concentric streets and radiating avenues. They were to contain the family quarters, with a sumptuous officers' club at the center. Around the perimeter would be the major headquarters, the Hospital, the Chapel, the base theatre, and other public buildings. Behind these—but still within the rectangle—were to be the cadets' and enlisted men's barracks, dining halls, athletic fields, and squadron working units.

Airplanes would operate from the broad band of turf on both sides of the rectangle and at its south end too, if necessary. At no point on the base would an officer or airman be more than five minutes away from the flight line in case of an emergency.

It took three years to convert these plans into the handsome reality that was Randolph Field. The cost was $11,750,000—no

trifling sum in the midst of the deepest and most lingering business depression the nation had ever known. All the buildings were solid and spacious, incorporating a variety of discreetly elegant achitectural touches in their design. The style was a semitropical blend of Mediterranean, Spanish Mission, and Moorish influences.

Displayed in countless magazine articles, feature films, and news reels in the nineteen-thirties as "The West Point of the Air," Randolph Field became a symbol of America's reviving strength in military aviation. It could be recognized at a glance by the 175-foot tower (masking a water tank) above the Training Center Headquarters, known to a generation of flying cadets as "The Taj Mahal."

The building created for the School of Aviation Medicine was next to the Hospital on the Main Circle, near the southwest corner of the base. It was several times as large as the building at Brooks Field, with lecture halls, offices, and examining rooms on the two floors above ground and space for laboratories in the basement. Construction started on the building in May 1931. On October 30 the School moved in, ten days after the Primary Flying School arrived from Brooks. The Advanced Flying School remained at Kelly.

Here at Randolph, the School of Aviation Medicine was to carry on its work undisturbed for the next 28 years. As time went on, it would begin to enjoy unparalleled growth in its outlook and its reputation. Yet this change—apart from the physical surroundings—was not immediately evident. The size of its staff was to be nearly constant for the better part of a decade. The duties of the staff at Randolph were much the same as they had been at Brooks.

The research program was placed on a somewhat more formal basis, was considered a facet of the School's official activities, and was better supported. But the emphasis on cadet selection continued as before—particularly in the areas of neuropsychiatric personality tests and psychological evaluations, as opposed to physiological standards derived from high-altitude studies.

Major Benjamin B. Warriner had relieved Major Poole as commander in the autumn of 1930. It was his task to superintend the move to Randolph. After Captain Mashburn left for the

Philippines in the spring, Major Warriner also headed the Department of Psychology. Lieutenant Colonel Albert P. Clarke, who succeeded Major Warriner in the fall of 1932, followed the same precedent.

When Doctor Mashburn—now a major—returned to the School as director of Psychology in May 1934, he was astounded by one bit of news that awaited him. A few weeks earlier Mr. Asa Constable, the laboratory assistant who had helped him to design and build the Serial Action Complex Coödinator, had been granted a patent on it.[2] Although the Government was free to use the device without paying any royalty, private organizations also could buy it and operate it commercially—for example, to test the "flying ability" of customers at amusement parks.

In the dispute that followed, Doctor Mashburn threatened Mr. Constable with court action, while Mr. Constable asked for an investigation by the Army Corps Commander. (Nothing ever came of either strategem.) Partly because of this controversy, the Complex Coördinator was dropped by the School as a test apparatus in 1938. It was not to be revived until the vast expansion of pilot procurement and training in World War II.

Even with the improvements which he had made in its operation, the Complex Coördinator had never fully realized Doctor Mashburn's hopes for it. He had been looking for an instrument which would give an absolute—or nearly absolute—prediction of flying ability. During the three years that he used the automatic model after his return from Manila, the ratio of cadets graduated by the Training Center ranged from 77 per cent of those who had made the highest scores down to 16 per cent of those in the lowest group.

There seemed to be no way in which the test scores on the Coördinator could be made more accurate. Yet there remained the frustrating fact that 23 per cent of the most promising subjects failed to qualify as pilots, while 16 per cent of those who seemed to have no aptitude for flying went on to receive their wings.

Moreover, despite the whole-hearted concentration of the School on selection tests, the elimination rate in pilot training still was high. Of the 3,019 cadets enrolled at Randolph from 1931 through

1937, only 43.2 per cent were able to complete their advanced flight training at Kelly. This was a far better record than the low of 17 per cent which had brought the School of Aviation Medicine to Texas. But it hardly satisfied the hope in Washington that scientific selection and intensive medical care of the candidates in training would virtually do away with failures.

So the School went on doggedly searching for other kinds of aptitude tests that might conceivably do better. After Lieutenant Colonel Clarke's relatively brief term as commander ended late in 1933, the Air Corps chose an outstanding flight surgeon and administrator, Lieutenant Colonel Arnold D. Tuttle, to succeed him, and left the departmental programs to learned specialists like Doctor Mashburn. Colonel Tuttle retired in 1937 to become the Medical Director of United Airlines.

He was followed by Lieutenant Colonel Coleridge L. Beaven, who went on to Washington in 1939 as Chief Surgeon of the Air Corps. The successor to Colonel Beaven was Lieutenant Colonel Fabian L. Pratt, the only commander of the School up to that time who was a rated pilot as well as a flight surgeon. Colonel Pratt would be in charge until a few weeks before the entry of the United States into World War II.

On the whole, despite the disappointing outcome of its efforts to measure flying ability, the first decade spent by the School at Randolph was both personally and professionally rewarding. From the personal aspect, Randolph was an agreeable place to be assigned during the long-drawn-out recovery from the economic depression of the early nineteen-thirties. Remote from the turmoil of industrial areas, in a state which had suffered less from unemployment and privation than some others with fewer natural resources to be exploited, Randolph was rather like a self-contained military post in an outlying land such as Hawaii or the Philippines.

Professionally, the thirties were a period in which aviation medicine formulated a clearer view of itself as a separate specialty within the body of medicine as a whole, developing organs for the exchange of knowledge and opinions among its own members.[8] This movement had begun in October 1929, when a group of military and civilian flight surgeons led by Dr. Louis H. Bauer had met in Detroit to form the Aero Medical Association.

Until the organization of the Aeronautics Branch in the Department of Commerce, with Doctor Bauer as its Medical Director, the only practicing flight surgeons and medical examiners had been those on active duty in the Army or the Navy air service. The professional group with which they had traditionally allied themselves was the Association of Military Surgeons of the United States, founded in 1891 and incorporated by an Act of Congress. As it happened, the newly elected President of the Military Surgeons in 1929 was one of the founders of aviation medicine, Dr. William H. Wilmer, then a brigadier general in the Medical Reserve Corps of the Army.

Even though the medical staff of the civil aeronautics authority consisted almost entirely of former military surgeons, Louis Bauer naturally wanted to stress their interest in civilian aviation. Moreover, he felt that the medicine of flight had reached a point where it could be considered a distinct branch of the healing art, different in principle from the applications of the older specialties in other areas of military medicine.

For the first few years of its existence, the Aero Medical Association was largely supported by the civil aeronautics administration in Washington. Its President for three successive years was Louis Bauer himself. He was followed by Dr. Ralph N. Greene, one of the first civilian medical examiners appointed by Bauer in 1927, who later became the Medical Director of Eastern Air Lines. After Doctor Greene, the next seven presidents of the Association were civilian medical examiners for the Department of Commerce.

In fact, it was not until 1941 that a military surgeon on active duty was elected President of the Aero Medical Association for the first time. He was Navy Captain John R. Poppen, a graduate of the School of Aviation Medicine nineteen years earlier, then serving in the research division of the Navy Bureau of Medicine and Surgery.

But the military flight surgeons were not disturbed by the seeming reluctance of the Association to recognize their leadership in aviation medicine. Rather, they were often wary of accepting office in the society, on the ground that its forthright interest in legislative questions might compromise their relations with Congress and the executive branch of the Government. It was a time

when American military officers not only avoided any expression of their political sentiments, but were guarded too in their fraternization with civilian groups except under the most obviously social or professional circumstances.

They attended the annual meetings of the Association in Chicago, Washington, Los Angeles, New York City, and once—in 1935—in San Antonio. There they discussed current problems of mutual interest with their military and civilian colleagues, and presented papers describing their clinical observations or the results obtained from experimental research. On the other hand, they were glad to let the Civil Aeronautics Administration and the growing coterie of airline medical directors manage the affairs of the Aero Medical Association.

The Journal of Aviation Medicine appeared for the first time in March 1930. Thereafter it was published quarterly by the Association throughout the nineteen-thirties. It gave the flight surgeon an organ of his own in which to record studies of some permanent significance on the medical aspects of aviation. For subjects appealing to a wider audience, either in the field of general medicine or in one of its traditional areas, he had access as before to the *Journal of the American Medical Association*, to the publications of the various state medical societies, to *The Military Surgeon*, and to the many journals of established specialties.

In its own leisurely fashion, aviation medicine continued to spread abroad.[4] The third medical officer from outside the borders of the United States to attend the School of Aviation Medicine, in the fall of 1930, was another Cuban Army surgeon, Lieutenant Tomás R. Yanes y Rojas. The fourth came from the other side of the Earth. He was Major Joseph Lee Shiang-min of the Chinese National Army, the first of a long succession of graduates from China and other nations of the Near and Far East.

Doctor Lee received his diploma in May 1933. After World War II, when the Chinese National Republic transferred its forces to the Island of Taiwan, contact with Doctor Lee was lost. He was one of five Chinese graduates whose later careers and whereabouts were unknown.

The next year, Captain Pelagio G. Potenciano arrived from the Philippines. Although the Philippines then were an overseas ward

FIGURE 12 —

Flight surgeons talk to pilots on a flight line at Randolph Field, Texas in 1932.

FIGURE 13 —

The School of Aviation Medicine moved to this building at Randolph Field, Texas in 1931.

FIGURE 14 —

This is the famed aviation pioneer Wiley Post in an early pressure suit in 1934.

of the United States, they had been promised their independence. After they achieved it at the end of the War, Doctor Potenciano advanced to the rank of colonel and became the Surgeon General of the Philippine Air Force.

He was followed in 1935 by the late Major Manuel G. Olympia, also from the Philippines, and in 1939 by Lieutenant Trajano V. Bernardo, who retired after the War as a major.

In 1935, too, the School graduated its first student from Mexico, Major Raul Terrés Prieto. As a brigadier general, Doctor Terrés Prieto was to be the Surgeon General of the Mexican Air Force and an internationally known authority on aviation medicine.

Other graduates from abroad in the nineteen-thirties were Major Julio Cesar Aguilera S. of Mexico, later a colonel, and lieutenant Francisco Hernández d'Abrigón of Cuba. They brought the roster of flight surgeons outside the United States to only ten, in five other nations of the Western Hemisphere and Asia. Nevertheless, they were a sign that interest in aviation medicine elsewhere in the world was increasing.

In November 1939 the School at Randolph graduated its last group of Navy flight surgeons. After an association with the Air Corps School covering seventeen years, the Navy had decided to establish its own School of Aviation Medicine in conjunction with the Naval Air Training center at Pensacola, Florida.

Flight operations in the Navy were carried on under conditions which were seldom encountered by Army pilots. Most of these flights were over water, often from the decks of aircraft carriers or other fighting ships, raising special problems of rescue and survival after emergency landings at sea. The Navy felt that its flight surgeons ought to be familiar with all of these problems. For the same reason, the Navy required its flight surgeons to qualify as naval aviators.

For nine years after the Air Corps School had moved to Texas, the Navy had assigned no medical officers to its classes. Instead, they had been given an abbreviated course in flight therapy at the Naval Medical School in Washington. That expedient had been less than satisfactory. Since 1935, Navy surgeons had attended

the course at Randolph again, while they had waited for the opening of the new School at Pensacola.

Although the Navy's action reduced the scope and authority of the Air Corps institution as a unique academy of its kind, the effect was to broaden the services provided in the specialty of aviation medicine. Moreover, the Navy School was largely patterned on the one at Randolph. Its first three commanders had attended the Army School while it was still on Long Island. In a very real sense, the institution at Pensacola was an offshoot of the original School created by Lyster and his colleagues, carrying on closely related studies.

Nor was this the only offshoot of the older School in the nineteen-thirties. A year earlier, in Kansas City, the Civil Aeronautics Administration had inaugurated a Medical Service Station for research on the cause and prevention of flight fatigue in commercial pilots. It derived its basic knowledge and its methods from the School at Randolph.

Even earlier, in 1935, at Wright Field, Ohio, another medical research laboratory was organized by the Air Corps under conditions that recalled the founding of the Laboratory at Hazelhurst. That institute was first to complement, for a while to overshadow, and in time to rival the School in Texas. Together, they would share responsibility for the rise of aerospace medicine over the next quarter of a century.

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Chapter 8

ANOTHER LABORATORY

While the School of Aviation Medicine was absorbed in its effort to predict flying ability in the nineteen-thirties, technical changes of enormous consequence were at last occurring in American aviation.[1] Since the reorganization of the Air Corps in 1926, the obsolete biplanes of wood and fabric left over from World War I had been discarded. They were replaced by a succession of all-metal monoplanes with more powerful engines, capable of flying longer distances at greater speeds and higher altitudes. The open cockpit was covered by a canopy, and then, in larger aircraft, became an enclosed cabin.

The climax of this modernization program was the Boeing B-17 bomber, renowned as the "Flying Fortress" of World War II. The first four-engine bomber put into actual service by the Air Corps, it was test-flown successfully in the summer of 1935 and delivery began a year and a half later. The B-17 could carry a full bomb load several thousand miles at an average speed of 230 miles per hour, leaving behind many fighter planes at that time. Without bombs, it could reach a height of about 30,000 feet.

That was by no means a record altitude. Several pilots in specially equipped aircraft had by then flown above 40,000 feet. In 1938 an Italian aviator, Colonel Mario Pezzi, climbed to 56,046 feet (10.6 miles), a record that was to stand unbroken for the next decade. But the B-17 was an operational airplane, built to fly at an altitude where it would be less vulnerable either to ground fire or to fighters diving on it from above. More advanced bombers, then on the manufacturers' drawing boards, would be able to reach still greater heights.

To protect the crews of those future bombers from the unpleasant effects of high altitudes, without requiring them to wear

bulky garments and equipment which would hamper their mobility, the designers were planning to enclose them in pressurized cabins. Beginning with the B-29, the airplane's engines would draw a quantity of tenuous air into the crew compartments from the atmosphere outside and compress it, to provide a comfortable interior atmosphere equivalent to the natural environment at a mere 8,000 feet or so.

But the prospect of a pressurized cabin raised another question which was new to aviation medicine in this context. What would happen if the cabin wall was pierced by enemy fire or by some accident or failure, releasing its pressurized atmosphere almost instantaneously in what was known as an explosive decompression, and exposing the crew to the rarefied air around it?

The question had seemed to be a more or less academic one back in the nineteen-twenties, when the Army had still relied on the lumbering open-cockpit bombers of World War I. Although the effects on the body of rapid decompression in fast ascents had been explored long ago—by Dr. Paul Bert, for one—no one had imagined then that a flyer could, so to speak, be transported in an instant from an altitude of less than 2 miles to an altitude of 6 miles or more. But now that crews were actually flying at these relatively lofty heights, the need for an answer was becoming more urgent.

Other questions were posed by the rapid rise in aircraft speed and altitude. What chance had the airman to survive if he bailed out of a stricken plane above 30,000 feet? How well would a parachute work, and how would he get enough oxygen to keep him alive in his descent? What equipment did the fighter pilot need in his unpressurized cockpit, with only a plexiglas canopy between himself and the approaches to the stratosphere? What were the stresses on the body from tight turns and other manoeuvres, performed at several times the speed of World War I airplanes?

The Air Corps could turn to at least two highly qualified engineering agencies for information about the physical effects of speed and altitude on the structural components of the airplane. There was, for example, the National Advisory Committee for Aeronautics at Langley Field, Virginia. It was an independent research organization created by the Congress in 1916 to assist the aviation industry—as well as the air services of the Army and

the Navy— in just such matters. Too, there were the modern engineering laboratories and test facilities of the Air Corps' own Materiel Division at Wright Field, outside the city of Dayton, Ohio.

But the engineers had no training in the effects of these novel stresses on the pilots who tested and flew the aircraft. Since the dissolution of the Department of Physiology at the School of Aviation Medicine, a decade earlier, there was no authoritative source to which the Air Corps could turn for knowledge about the human consequences of exposure to these exotic forces and conditions.[2] The School now was occupied almost exclusively with cadet selection tests and the general health of student flyers. It had no equipment at Randolph Field for high-altitude research.

The flight surgeon at Wright Field in the early nineteen-thirties was Major Malcolm C. Grow, an Army medical officer from Philadelphia who had served in France with the infantry and the artillery during World War I. Doctor Grow had turned to aviation medicine when he was forty years old, taking his diploma from the School in the spring of 1928. Now he was responsible for the safety of the test pilots who were trying out experimental airplanes and equipment in the skies over Dayton.

Major Grow soon realized that the knowledge he had gained at the School about the physiological effects of speed and altitude were outdated by a dozen or more years. He recognized, too, that the School was involved so deeply in other problems at the moment that it could not readily undertake this kind of research, and that it lacked the facilities besides. He felt that the research ought to be closely coördinated with the engineéring development and test activities carried on at Wright Field.

Early in 1933, Major Grow discussed the need for a physiological research unit with the Materiel Division. They gave him their blessing and a desk in the Engineering Laboratory; but no equipment of the sort he required for these experiments was available then at Wright Field either. Instead, Grow worked with the engineers on the proper design of clothing for high-altitude flight crews, on the accumulation of carbon monoxide from engine exhausts in aircraft cockpits, on the tolerance of flyers to varying concentrations of oxygen and carbon dioxide in closed cabins, and on other such practical—but hardly basic—problems.

Then, in the fall of 1934, Doctor Grow received a talented recruit to assist him with his project. Captain Harry George Armstrong, Flight Surgeon of the First Pursuit Group at Selfridge Field, Michigan, and Grow's junior by a dozen years, was reassigned to Wright Field as his replacement. Grow was awaiting orders to report for duty in the Medical Division at Air Corps Headquarters in Washington.

Born on a farm in South Dakota, Harry Armstrong had the urge of a boy who had grown up in rural surroundings to investigate whatever was new or strange to him. During World War I, he had interrupted his schooling to serve as a private in the Marine Corps. After the War, he had studied medicine, taking his degree at the University of Louisville in 1925.

For several years he had practiced as a physician in Minneapolis. When the daily rounds of a young doctor had begun to pall on him, he had applied for a commission as a medical officer. Appointed in the spring of 1929, he had attended the School at Randolph, receiving his accreditation as a flight surgeon later in the year. From Randolph he had gone on to the Army Medical School in Washington and the Medical Field Service School at Carlisle Barracks, Pennsylvania. Now 35 years old, Doctor Armstrong was keenly interested in aviation and had a natural bent toward experimental research.

Grow promptly infected Armstrong with his own enthusiasm for the idea of a physiological laboratory at Wright Field. Then he went off to Washington, leaving his new-found protégé to carry on with the work which he had begun, while he busied himself with explaining the need for the laboratory to the Surgeon General and to other influential officers at Air Corps Headquarters. The relationship between Grow and Armstrong was to be something like the one between Lyster and Isaac Jones in 1917.

In April 1935, Malcolm Grow—now a lieutenant colonel—became the Chief Surgeon of the Air Corps. At last he was in a position where he could himself exert influence for his project. He lost no time in arranging a conference with the Surgeon General and the Chief of the Air Corps to describe his plan. The Chief of the Air Corps was impressed. On May 29 he issued a directive to the Chief of the Materiel Division at Wright Field, formally

establishing the Physiological Research Unit as a branch of the Equipment Laboratory in the Division.

Funds were now available for the special equipment—including a low-pressure chamber—needed by the new research organization. While it was being designed and built, Armstrong assembled whatever useful apparatus he could find and set it up in the basement of the Engineering Laboratory.

His most exciting discovery was an ancient low-pressure chamber that Colonel Grow had overlooked. An upright cylinder of steel, 10 feet tall and 9 feet in diameter, it turned out to be the one which the School of Aviation Medicine had left at Mitchel Field in 1926, at the time of the hegira to Texas. From Mitchel, it had been shipped to the Materiel Division at Wright Field. There it had been used for a while to test the reliability of flight instruments at high altitudes. Since then, it had stood idle under an accumulation of dust in a dark corner of a storage room.

Doctor Armstrong had the old chamber reconditioned and refitted. For the next year and a half, he used it intermittently for preliminary experiments on the physiological effects of altitude, while he waited for the more advanced chamber which he had ordered. After that, it was discarded again, until another use would be found for it in World War II.

But most of Armstrong's experiments, during his first year at Wright Field, were conducted outside the confines of the laboratory. In the spring of 1935 he was the first flight surgeon to experience a free fall from an airplane.[3] He made the jump to show that—contrary to the belief of many aviators at the time—a free fall of more than 100 feet or so through the atmosphere would not necessarily result in unconsciousness, or even death, before the ground was reached.

To prove this point, he bailed out of a plane flying at an altitude of 2,200 feet with a ground speed of 119 miles per hour. Instead of pulling the ripcord on his parachute immediately, as a pilot ordinarily would have done, he delayed its opening for 11 seconds, allowing himself to fall 1,200 feet. At a height of 1,000 feet he let the chute blossom and floated safely to the ground.

His conclusions were (1) that no unpleasant effects were associated with the fall itself, and (2) that delayed openings were essential in certain situations—for example, to avoid entangling the chute in the aircraft or to get down quickly from a very high altitude to a level where the partial pressure of oxygen in the air was enough to sustain him. Armstrong calculated that it would take no more than a minute and a half to fall from a height of 30,000 feet to 15,000 feet, where the flyer would be safe from oxygen privation.

Later that year, Captain Armstrong was assigned as flight surgeon to the crew of the XC-35, an airplane with an experimental pressurized cabin, then undergoing tests at Wright Field. On the basis of his findings, he wrote the first detailed analysis of the medical requirements for a closed aircraft compartment at high altitudes.[4]

Still later in the year, Armstrong was appointed flight surgeon to the historic ascent into the stratosphere of the balloon *Explorer II*, carrying Air Corps Captains Orville A. Anderson and Albert W. Stevens suspended under it in a sealed gondola.[5] Jointly sponsored by the Air Corps and the National Geographic Society, the expedition was to collect scientific information on environmental conditions in the upper air. Captain Anderson was the pilot, Captain Stevens the observer and commander.

Explorer II embodied a life-support system more advanced even than the pressurized cabin. Its aluminum capsule, 9 feet in diameter, was completely air-tight. It carried its own atmosphere—a mixture of 46 per cent oxygen and 54 per cent nitrogen—continually refreshed from a cylinder of liquid gas. An atmosphere of pure oxygen had been considered, and would have been much simpler. It had been rejected because pure oxygen at low pressures could have touched off a disastrous fire.

A container filled with sodium hydroxide (caustic soda) absorbed the waste carbon dioxide from the air and reduced the humidity. A valve maintained the pressure inside the gondola at 464.5 millimeters of mercury (Hg), equivalent to an altitude of 13,000 feet. An electric fan kept the air in circulation and condensed excessive moisture.

The top of the gondola was painted white to reflect the direct rays of the sun, while the bottom was painted black to absorb

heat radiated from the ground. Together, they maintained an interior temperature ranging between 10.4° and 43.7° Fahrenheit in the frigid upper reaches of the stratosphere. In effect, the cabin carried with it a climate comparable to the autumn weather high in the foothills of the Himalayas.

With its hatches open to the ambient air, *Explorer II* began its ascent at 7 o'clock in the morning on Armistice Day, November 11, 1935, from a field near Rapid City in Doctor Armstrong's native South Dakota. At an altitude of 16,700 feet, where the first symptoms of oxygen deficiency were noticed by the two-man crew, the climb was halted while the hatches were sealed and the life-support system turned on. Then the balloon started up again.

While Anderson and Stevens compiled the first series of exact measurements ever taken of atmospheric pressures, temperatures, the density and composition of gases, cosmic radiation, living bacteria, and visual phenomena in the upper air, the capsule soared to an altitude of 72,395 feet (13.7 miles), above all but 4 per cent of the Earth's atmosphere. At 3 o'clock in the afternoon they were on the ground again, unharmed.

From the medical point of view, they had shown that in a sealed compartment, provided with its own self-renewing atmosphere, men could survive at any distance from the Earth to which their vehicles could take them. As Doctor Armstrong wrote, somewhat more cautiously, in his report to *The Journal of Aviation Medicine:* "The recent intense interest in high-altitude flight . . . throughout the world indicates that eventually stratosphere flying will possibly become routine, and the knowledge gained on this flight will then form the physiological basis for passenger cabin design."

For more than a year, while this extraordinary outburst of creativity was under way, Captain Armstrong was alone in his improvised laboratory. Then, in June 1936, he was joined by a young assistant, John W. Heim, Ph.D., as Associate Physiologist. Doctor Heim had been a research fellow and lecturer on physiology at the Harvard University School of Public Health. He was to fill much the same key position in research for the unit at Wright Field that Professor Schneider had occupied with the Laboratory at Mineola during its formative years.

The new experimental laboratory was ready for Armstrong and Heim on January 1, 1937. It was enclosed in an area of about 3,600 square feet on the ground floor of the same building in whose basement they had been working for some months.[6] In addition to the office and storage rooms, it contained three large laboratories for physiological studies, biochemical analysis, and high-altitude experiments, a smaller altitude laboratory, a dust-proof room for analytical balances, and a small operating room. The whole area was air-conditioned—a novelty even in scientific institutes at the time.

The most impressive feature of the laboratory was its low-pressure chambers. The largest was a horizontal cylinder of steel 8 feet in diameter and 31 feet long. It was divided into three compartments, the central one serving as an entrance and air-lock, with separate air-tight sections for experiments on both sides of it. The atmosphere in any or all of these compartments could be exhausted to about 22 mm Hg— less than 3 per cent of the normal pressure at sea level, and comparable to an altitude of 80,000 feet or 15 miles. The temperature within them could be reduced to 65° below zero Fahrenheit.

Two small chambers, each of 3 cubic feet capacity, were used mainly to examine the effects of low pressure and low temperature on biological specimens.

In a section of the balloon hangar at Wright Field the laboratory had another unusual piece of equipment. It was a human centrifuge, consisting of an arm 20 feet long, rotating horizontally around its axis. With an electric motor, operating through a variable-speed drive, the centrifuge could produce acceleration forces up to 20 times the normal force of gravity on a human subject at the end of the rotating arm. The object was to investigate the dynamic effects of high-speed turns and other aircraft manoeuvres on the pilot.

With these devices alone, the Physiological Research Unit at Wright Field became the most advanced laboratory for the study of human responses to high speed and high altitude then in existence. For the next few years, it was to serve the same unique purpose for which the Laboratory at Hazelhurst had been

founded, without the distraction of the teaching functions which had been imposed upon its predecessor.

As might have been expected, the School of Aviation Medicine at Randolph had watched the growth of the new laboratory at Wright Field with some misgivings.[7] Under the terms of its original charter from the Medical Research Board in 1917, the School was responsible for all research having to do with the safety and efficiency of pilots, including the development of oxygen equipment and other devices to sustain them at high altitudes. Even though the School had suspended its physiological studies more than a decade earlier, and was preoccupied with other problems, the staff was accustomed to display a more or less proprietary attitude toward experiments in aviation medicine generally.

During 1935, while the Wright Field laboratory was taking shape under the paternal eye of Colonel Grow, a series of letters had passed back and forth between the Air Corps Training Center at Randolph, the Materiel Division at Wright Field, and Air Corps Headquarters in Washington, to determine which organization had authority over what areas of flight safety research. The result had been an agreement that Wright Field would concentrate on medical projects related to the development of equipment for flyers, while the School would give its attention to those involving "personnel factors." Each institution had dropped some minor research projects that impinged on the other's preserve.

Eventually, this agreement would evolve into a more or less tacit understanding that the Wright Field laboratory was concerned with applied research and development in the field of medical engineering, and the School at Randolph with basic research on the responses of the aviator to the flight environment as a whole. Even this understanding was to be more a matter of emphasis than a clear line of demarcation between the two programs.

In exploring basic problems that affected the health and safety of the flyer, the School would often find that its research led to the development of a new device with which to solve the problem. Conversely, in the search for improved life-support systems, more often than not the laboratory at Wright Field found that it had to

conduct exploratory studies in order to define the basic problems more precisely, turning up important new knowledge in the process.

The consequent overlapping of their programs was rarely a hindrance to either institution. On the contrary, it was a challenge and a stimulus to both. The results which were to come from their competition would more than balance the duplication in effort.

During the six years that Doctor Armstrong directed the new laboratory, its energy, enthusiasm, and influence in the field of aviation physiology far outstripped its growth in size or physical resources.[8] From its official opening in 1937, the laboratory gave annual presentations on its work at the meetings of the Aero Medical Association. In 1938 the Association met in Dayton, so that it could view the work of the laboratory in its own setting.

The program that year included the first report by Dr. Walter M. Boothby on the novel BLB oxygen mask, jointly developed by Doctor Boothby, Dr. W. Randolph Lovelace II, and Dr. A. H. Bulbulian to provide a self-regulated mixture of pure oxygen, air exhaled from the lungs, and atmospheric air during flight at moderately high altitudes. This project was the result of a close relationship formed by Armstrong with a group of Air Corps Reserve specialists in aviation medicine at the Mayo Clinic in Rochester, Minnesota. Their collective research on pilot fatigue, high-altitude effects, the airlift of patients with respiratory problems, and related questions earned the Collier Trophy for Armstrong, Boothby, and Lovelace together in 1940.

Armstrong himself wrote thirty or more published papers on varied aspects of his research at the laboratory, some of them in collaboration with Doctor Heim. In his spare time, he completed the requirements for a master's degree in science at the University of Cincinnati, receiving the diploma in 1940.

The climax of his work at the laboratory came in 1939, with the publication of his book, *Principles and Practice of Aviation Medicine*. It was the first inclusive text covering all the complex and diversified medical problems encountered in modern flight. Revised in successive editions over the next decades, it was to be accepted as the standard authority on aerospace medicine and the primary source of information in every flight surgeon's library.

As a further testimony to his industry as well as his first-hand knowledge of the pilot's problems, Armstrong collaborated with his friend and patron, Malcolm Grow, on a book of more general interest, *Fit to Fly: A Medical Handbook for Fliers*, published in 1941.

During most of this productive period, the laboratory at Wright Field—like the School at Randolph—was concerned only with the technical and scientific aspects of its work, and not with the prospect that these ideas and devices might contribute directly to the survival of Anglo-American civilization in another great war. As late as the autumn of 1938, after the German occupation of Czechoslovakia, most Americans accepted the slogan of 1917, that World War I had been "a war to end war," and that no armed conflict on the same vast scale was possible again. The peace conference at Munich seemed only to have confirmed this belief.

The depression with its long-lasting consequences (one was the recession which they were then experiencing) had persuaded Americans that all serious problems were economic problems, and that these difficulties could be solved by enlightened laws and imaginative plans formulated in Washington. They saw the Fascist and the Nazi movements abroad as European methods of solving the same problems, the military panoply accompanying them as a kind of pomp and circumstance peculiar to the Old World. In any case, they considered that the problems of Europe were no concern of theirs.

Less than a year later, in September 1939, the German Army invaded Poland and World War II began. Even then, it took two more years to convince the great majority of Americans that this was indeed another real war, on a scale even vaster than the one which the experience of 1914-1918 had made "impossible," and that they would inevitably become a part of it.

On May 30, 1940, as the German panzer divisions were rolling through Belgium on the highways to Paris, Captain Armstrong was relieved as director of the laboratory at Wright Field—now known as the Aero Medical Research Unit—and was assigned to the University of Toronto for a year of study as a research fellow. For the next three months, while France fell, the beleaguered British troops were rescued from Dunkirk by a fleet of small boats,

and the aerial assault on Britain was beginning, Doctor Heim served as acting director of the laboratory.

The successor to Armstrong arrived in September. He was another energetic flight surgeon, several years younger than Armstrong, with a similar taste for research. Captain Otis Otto Benson Jr. was the son of a physician in Sandstone, Minnesota. He had received his medical degree from the University of Chicago's Rush Medical College in 1930, had entered the Army medical service shortly afterwards, and had completed the course at the School of Aviation Medicine two years later.

Doctor Benson came to Wright Field from the Mayo Clinic, where he had worked with Doctors Boothby and Lovelace, and from the Fatigue Laboratory at Harvard University. Thus he was well grounded already in the experimental areas which the Aero Medical Unit was exploring. His own accomplishments in research were to bring him national recognition. In the august company of Louis Bauer, Harry Armstrong, Professor Schneider, Malcolm Grow, and Doctor Lovelace, among others, he would be honored by the Institute of the Aeronautical Sciences with the John Jeffries Award, for contributions to the advancement of human flight through medical science.

Moreover, Captain Benson had a marked talent for organization. Although his tour at Wright Field lasted less than three years, he set in motion the process of expansion in its staff and physical facilities that was to raise the Unit—by then known as the Aero Medical Laboratory—to the status of a major research institution by the end of the War. Even before he left, the Laboratory would have grown to three divisions, for physiology, biophysics, and clinical studies, in a new and more spacious building of its own. Like the Laboratory at Hazelhurst before it, the Wright Field establishment would swell with an influx of civilian specialists in uniform and bright young officers.

In short, the trio of Grow, Armstrong, and Benson had filled the vacuum left by the closing down of physiological research at the School, replacing it with an independent laboratory that was to become even larger and better known as time went on. Nor was that all. Just as Lyster, Wilmer, and Jones had created aviation medicine out of a few tenuous ideas in World War I, so

the team of Grow, Armstrong, and Benson would evolve from it an infinitely grander realm of study and practice, detached even from the atmospheric flight environment around the Earth. Aerospace medicine, as they were to shape it over the next two decades, would reach beyond any physical boundaries in the universe, toward the ultimate distances that man-made vehicles might hope to attain.

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Chapter 9

ANOTHER WAR

Up to a point, World War II appeared to be a repetition of World War I with minor variations. The same European nations were engaged, although some of them had changed sides. After the opening campaign in Poland and a winter of suspense, the same pattern was followed, consisting of a German thrust through the Low Countries into France. Again Germany relied upon a fleet of submarines in the Atlantic to keep the strength of the United States at a distance until the issue was decided.

Yet it soon became evident that this was in fact a very different kind of war. For one thing, it covered a much vaster field of action. From the beginning, it extended far beyond the continent of Europe, to the Southwest Pacific and the mainland of Asia. There Japan, as a major ally of Germany, already occupied large areas of China and threatened the colonial empires of England, France, and The Netherlands.

In an even more fundamental respect it was a different war. Instead of lapsing into a state of prolonged inertia, it was a war of lightning movement. Virtually all of its equipment was mechanized. Armored columns pierced the opposing positions and enveloped them within a few hours. Poland was overrun in less than a month, Norway (except for its north coast) in three weeks, Holland and Belgium in five days.

Tactical aircraft accompanied fighting ships and armies, enormously augmenting the range and accuracy of their fire. Strategic aircraft penetrated many hundreds of miles behind the opponent's lines, crippling his supply routes and bases. Airborne troops were dropped on cities like Rotterdam, on islands like Crete. Air transport ferried men and supplies over disputed seas to distant theatres such as North Africa.

Air power no longer had to be conveyed across oceans in slow-moving surface convoys, as the American Air Service had been patiently assembled in France during the interminable months of 1917 and 1918. Now it could be dispatched on its own wings, with its own supplies, to any part of the world where it was needed, arriving in a matter of days. Only the ground forces for a large-scale landing on a foreign shore still were dependent on ocean vessels.

The great speed and technical efficiency of modern war were brought home fully to the United States for the first time in June 1940, when France capitulated after a campaign lasting only five weeks. The land mass of Europe now was in the hands of Germany and its allies. An invasion of the British Isles was expected in the months ahead. Only a swift and massive effort by America could save the English homeland from destruction.

The effect of this realization on the Air Corps was spectacular.[1] During the early phase of the War on the plains of Poland, the War Department had raised its pilot training quota from 300 a year to 1,200 a year. A few months later, after the occupation of Norway and the German breakthrough in Belgium, the objective jumped to 7,000 a year. In July 1940, after the fall of France, it mounted sharply again to 12,000 pilots a year. This forty-fold expansion reflected the War Department's estimate of the aerial armada needed to defend Britain.

And that was not the end. By February 1941, when it became evident that the invasion had been abandoned for the present and that it might be possible to carry the air war against the Germans to the European mainland, the quota was raised to 30,000 pilots a year.

As in 1917, on a vastly enlarged scale, the candidates for training had to come from civilian life. As before, this meant that the Air Corps would need many more aviation medical examiners to evaluate the applicants, and flight surgeons to watch over them in training and afterwards.

Over the twenty-two years from 1919 to the summer of 1940, the School of Aviation Medicine had graduated 490 flight surgeons.[2] (Another 67 had taken an extension course from the School, completing the practical work at Army fields near their homes.)

Some of the graduates had been medical officers of the Navy or of other nations. Some had gone to the Civil Aeronautics Administration or to the airlines, had retired for age or disability, or were dead. Even if all of those who still were eligible had been called to active duty, there would have been nowhere near enough of them.

In December 1939, when the Air Corps had raised its annual requirement for new pilots to 1,200 after the conquest of Poland, the School had cut the length of the flight-surgeon course from four months to three months. At the same time, it had increased the pace of its instruction from a leisurely thirty hours each week to a brisk thirty-eight hours or more. By this means, instead of slicing 25 per cent off the total class time, it had held the reduction to less than 10 per cent—from about 500 hours to 457. Only two classes, with a dozen flight surgeons in all, had been graduated under the new schedule.

On May 27, 1940, when the collapse of France was imminent, the Chief of the Air Corps—Major General Henry H. Arnold—dispatched a letter advising the School that the length of the course should be cut in half, to six weeks. Wrote the General: "With the contemplated increase in the training program of the Air Corps, a great strain will be thrown on the available surgeons in . . . examining and qualifying a sufficient number of trainees. It is estimated that a minimum of 50,000 physical examinations will have to be made . . . in order to obtain 12,000 trainees within the next twelve months."

General Arnold estimated that 250 flight surgeons could be trained in the year ahead by shortening the course and increasing the size of classes. The program was to begin at once, with the class assembling on July 15.

To preserve the integrity of its professional training, the School modified General Arnold's plan in one particular. From now on, the graduates no longer were accredited immediately as flight surgeons. Instead, they were qualified as aviation medical examiners. To be designated as flight surgeons, they were then required to practice for a time in the field, until they satisfied their seniors that they were ready for the higher rating, with the broader responsibilities to the flyer which it entailed.

Besides, the teaching schedule was increased again, to almost sixty hours a week. With a total of 352 hours' instruction, the student officers would still receive about 70 percent of the material presented under the old four-month course, in roughly one-third of the time.

Thus began the tremendous expansion of the School during the second World War.[3] From 32 graduates of the flight-surgeon course in 1939, the total climbed to 102 in 1940, and went on rising steeply to a maximum of 2,277 in 1943. By the end of 1945, the School would have trained 4,672 squadron physicians since the surrender of France to the Germans. (Besides, 149 would be accredited at other bases or by the authority of commanders in the field.) The total was to be almost ten times as many as the School had produced in the long period between the two wars.

To accomodate the hordes of student medical officers passing through its halls, the School would have to put up two more temporary buildings for the academic function alone. Because of the size of the classes, they would be subdivided into sections, often hearing lectures on aspects of the same subject in separate class rooms. As the teaching multiplied, more instructors were needed.

Nor were medical officers to be the only students trained by the School. Beginning in January 1941, a Flight Surgeon Assistant's course would be offered to medical corpsmen. They were taught to perform routine examinations under the direction of the Flight Surgeon. From July 1942 on, a succession of courses in high-altitude physiology would be provided for non-medical officers assigned to physiological training duties. Their responsibility was to instruct flyers in the effects of altitude and in the use of oxygen and other personal flight equipment. Still more teaching courses were to be added later in the War.

But the strongest impetus behind the wartime growth of the School at Randolph was not the expansion of its teaching programs, spectacular as that expansion would become. Instead, the impelling force came from the revival of research.[4] Ever since the first rumor that an experimental laboratory was to be established at Wright Field, the School of Aviation Medicine had been seized with an urge to resume its original place as a pioneer in high-

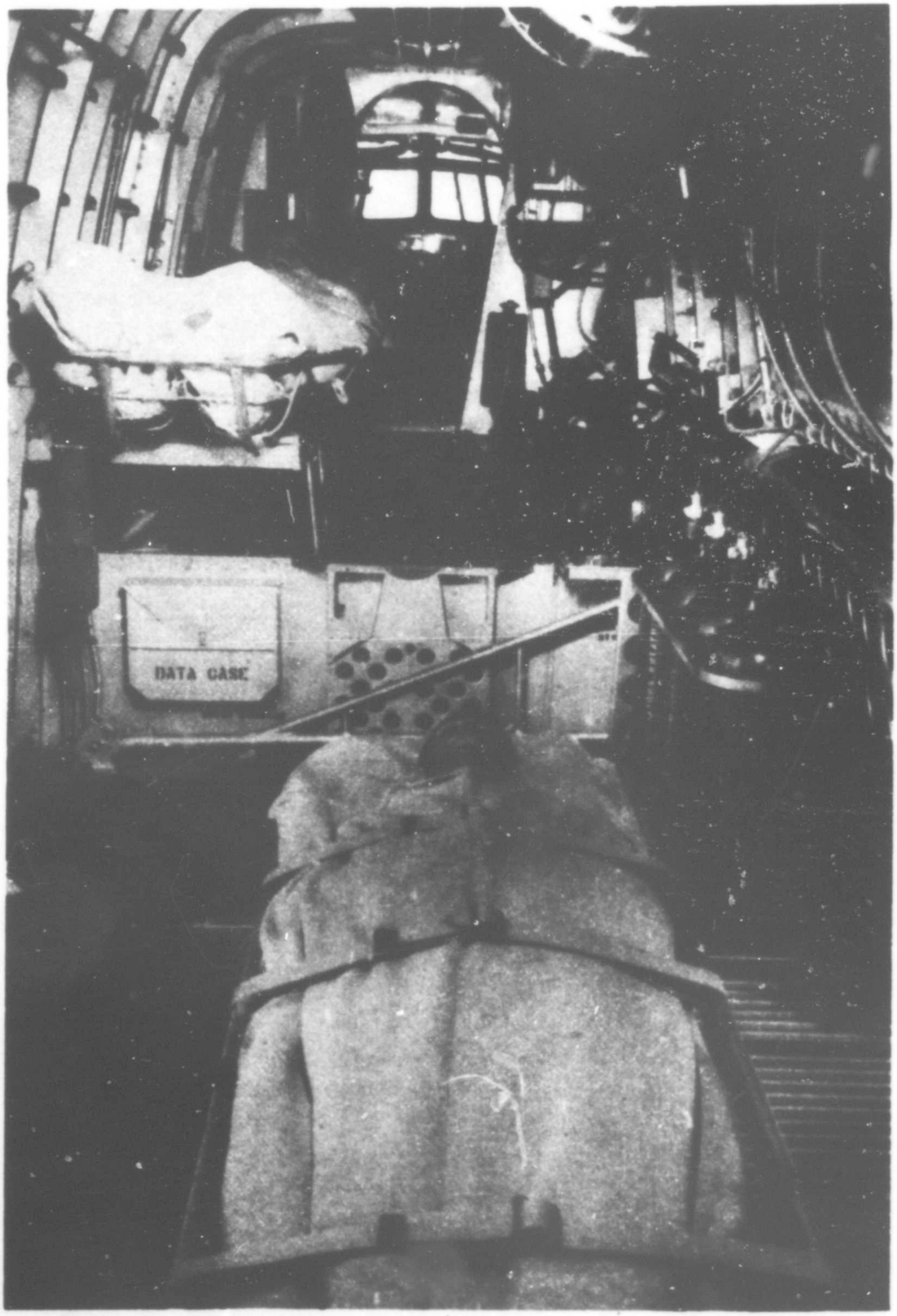

FIGURE 15 —

This B-18, modified to transport litter patients, was used by the School of Aviation Medicine, Randolph Field, in the 1930's.

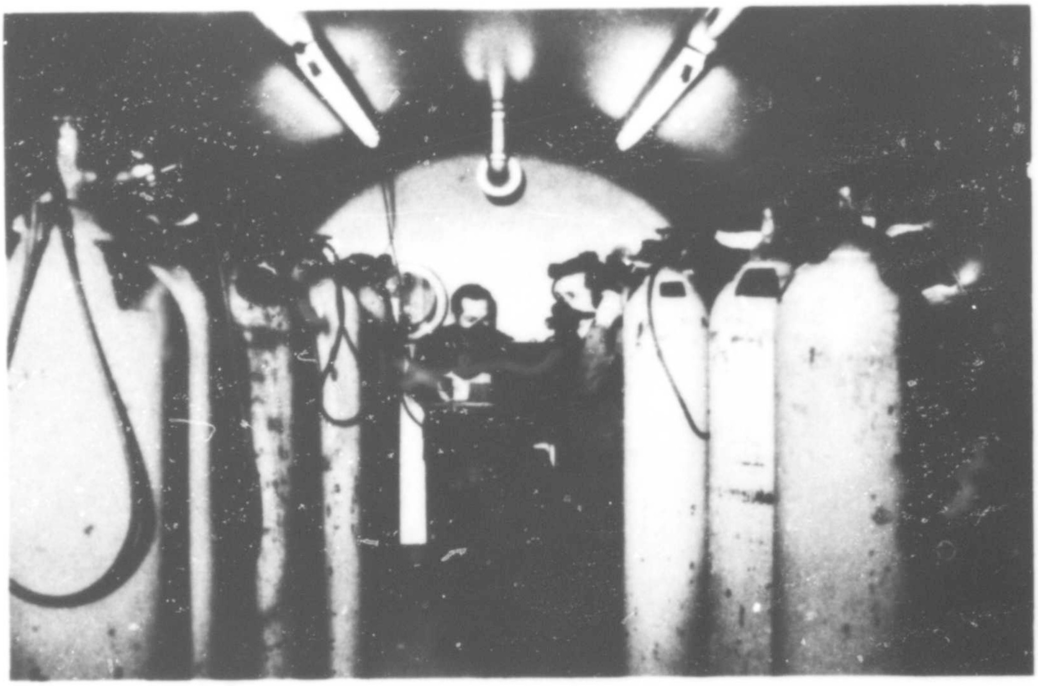

FIGURE 16 —

This is the interior of the first altitude chamber at the School of Aviation Medicine, Randolph Field, Texas in 1942.

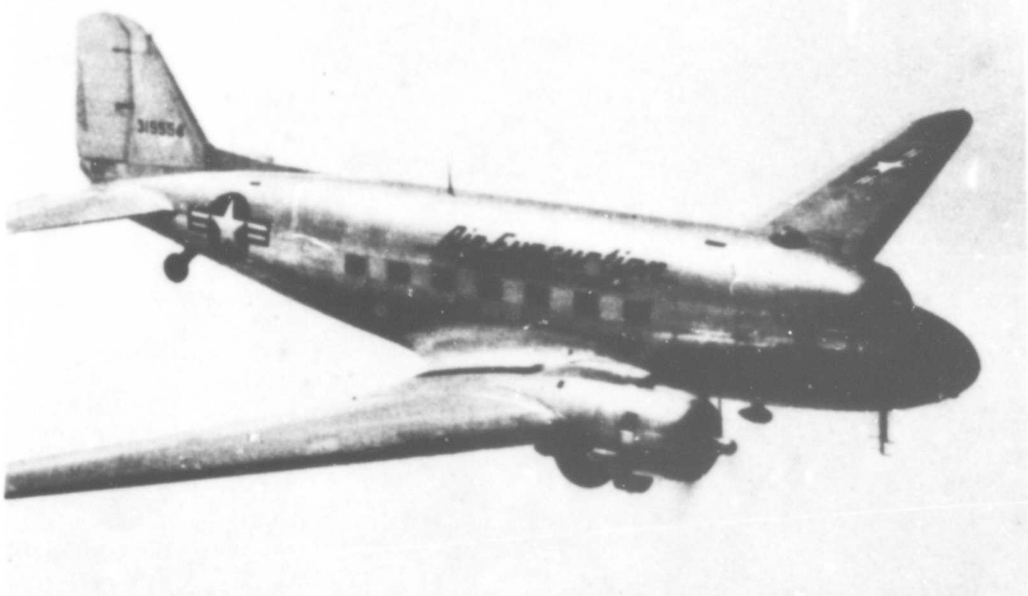

FIGURE 17 —

During World War II, the C-47 was the mainstay of the world-wide air evacuation system. Flight nurses and technicians were trained at the School for this operation.

altitude research. The War, with its vast extension of technology in flight as in every other field of human endeavor, supplied the justification.

As early as 1934, Lieutenant Colonel Arnold D. Tuttle—then the School commander—had recommended to Colonel Grow's predecessor as Chief Surgeon of the Air Corps that a separate department should be added to the organization at Randolph, with a full-time director, to develop a broadly integrated research program. At that time, funds to enlarge the staff and install new equipment had not been available, and nothing had come of the proposal.

But in the climate of 1940 the situation had changed. At the start of that year, Lieutenant Colonel Fabian L. Pratt—now the commander—had removed Physiology from Aviation Medicine and had restored it as a department in its own right, with its own head. Its prime function at first was in teaching. However, the means had been created for a resurrection of experimental inquiries into the effects of high-altitude flight.

Then in February 1941, as American resources were being mobilized for the rescue of Britain, Colonel Pratt renewed the plea of Colonel Tuttle for a comprehensive research effort. In a formal letter to the Chief of the Air Corps, he asked for authority and funds to establish an independent Research Division, with a staff of its own, exempt from any "routine teaching duties." The areas suggested for exploratory studies were aviation physiology, pathology, clinical and laboratory medicine, biophysics, biochemistry, neurophysiology, and psychology.

In April, he followed up this recommendation with a request for another permanent building at Randolph, comparable to the one then occupied by the School, to house the Research Division. In effect, what Colonel Pratt proposed was that the School should go its way as an adjunct of the Training Center, with the facilities it then had, and that another Medical Research Laboratory should be added to it.

This time, though, the response was favorable. On June 16, 1941, Colonel Pratt received his answer from the Chief Surgeon of the Air Corps, now Lieutenant Colonel David N. W. Grant. A

research fund had been set aside in the Medical Division at Headquarters. From it, an allotment was earmarked for the School, to establish a Research Laboratory independent of the teaching effort. The additional staff, the building, and equipment would be provided.

Thus the long eclipse of research at the School of Aviation Medicine was ended. Hereafter, research would expand without hindrance, reaching out to examine an increasing array of medical problems associated in some way with worldwide flight, until it would come to absorb a dominant share of the School's energies and interest.

In July 1941 the administrative system at the School was revised.[5] A Training Division was created to manage the educational function, with Lieutenant Colonel Walter A. Carlson—a flight surgeon and psychiatrist—as its Director. It retained the four traditional departments of Aviation Medicine, Ophthalmology and Otology, Neuropsychiatry, and Psychology. The Research Division was left in abeyance until the arrival of a Director from Air Corps Headquarters.

The basic group around which the Research Division would be built was the new Department of Physiology. But it would be free to institute others as it chose. In fact, within a year, Research would have experimental departments of its own devoted to aviation medicine, ophthalmology, otolaryngology, neuropsychiatry, and psychology, in addition to new ones for biochemistry, biophysics, pharmacology, physical fitness, and statistics. Besides, it would be responsible for the Library, the instrument shops, and medical photography.

By that time, a Division of Administration would be needed to coördinate all these interdependent activities with their supporting services. The Executive Officer in charge of administration would be the sole member of the staff remaining from the first days of the old Laboratory at Hazelhurst—Lieutenant Colonel W. Harvey Kernan, the Adjutant since his return to the School in 1938. By then, too, the total complement of the School would have grown from 24 to 109. It was to reach a maximum of 557 by the end of the War.

While Research was waiting for its Director, experimental studies were not suspended altogether at Randolph. The effort

to find better classification and selection tests for aviation cadets continued as before in the departments of Neuropsychiatry and Psychology. So far, no aptitude test more exact than Doctor Mashburn's Serial Action Complex Coördinator had been devised.

The Chief Surgeon of the Air Corps, Colonel Grant, now had taken over active guidance of medical research programs, leaving the educational effort largely under the supervision of the Training Center. One of the most urgent programs on Colonel Grant's list was a reliable system to identify prospective pilots, navigators, bombardiers, flight engineers, and other vital crew members, from among the increasing numbers of Air Corps recruits who were reporting at induction centers across the country.

In the spring of 1941, Colonel Grant wrote to the School for information on the current status of the Complex Coördinator.[6] Only two of the test devices could be found—one at the School itself and one at the Harvard University Fatigue Laboratory. Both were later sent to the Air Corps Replacement Center at Maxwell Field, Alabama, where Colonel Mashburn then was assigned. By the end of the War, the Complex Coördinator was to be acknowledged as the most accurate single piece of test equipment used by the Army to measure pilot aptitude.

But the Chief Surgeon had a larger project in mind.[7] It was a comprehensive research-and-test program, with batteries of specialized psychological examinations and psychomotor tests, from which the potential ability of individual air crewmen could be predicted with a high degree of certainty. In the inevitable residue of cases where the predictions failed, it was foreseen that the candidate often could be salvaged for another flight-crew position, calling for similar talents. For example, an air cadet washed out of pilot training, instead of being relegated to a job on the ground, might be converted into an aerial navigator.

To plan and manage this project, Colonel Grant had persuaded a pair of eminent civilian psychologists to join him in Washington. John C. Flanagan, Ph.D., had been in charge of the Coöperative Test Service of the American Council on Education. Commissioned as a major in the Air Corps Reserve, he became the chief architect and director of the Aviation Psychology Program as a whole.

Arthur W. Melton, Ph.D., was borrowed from the University of Missouri as a consultant. His task was to assemble and compare the many different psychological tests devised for the measurement of competence in other fields, to modify or supplement them through laboratory studies, and to advise the psychologists and technicians who would perform them on Air Corps recruits.

The actual testing was to be done by three Psychological Research Units attached to the Air Corps' new Aviation Cadet Centers at Maxwell Field, Alabama, at Kelly Field, Texas, and at Santa Ana Army Air Base, California. At the same time, the units would analyze the accuracy of the tests in identifying skills required for specific crew assignments.

Overall direction of the research effort was given to the School of Aviation Medicine. In August 1941, Professor Melton was offered a Reserve commission as a major, with the understanding that he would receive an appointment to the research staff of the School as soon as he was sworn in. He would not only conduct experimental studies to extend and improve the tests, but would coördinate the work of the three Psychological Research Units in evaluating them as well. Thus the units became, in a sense, field-test facilities of the School.

Unit No. 2 opened on the high bluff at the west end of Kelly Field (later to become a separate base called Lackland) on November 15, 1941. Of the three psychological test units, it was to be the most successful, possibly because of its close contact with the research effort at the School. At the end of the War, similar units from other fields would be combined with the one at Lackland. Its classification and selection studies were to increase in scope and profundity, until in time—as the Personnel Research Laboratory—it would evolve into the central agency providing human management techniques for the personnel system of the American air arm.

Meanwhile, on September 16, the new Director of Research arrived at the School of Aviation Medicine. The new Director was no less a personage than Harry G. Armstrong, recently promoted to the rank of major. From the University of Toronto, in the spring of 1941, he had gone to England on a temporary assignment at the United States Embassy in London, as Assistant Military

Attaché and a medical observor with the Royal Air Force, while plans were being considered for the deployment of American air units in Britain.

Back in the States—after pausing in Toronto to receive his master of science degree—Doctor Armstrong had joined the office of the Chief Surgeon in Washington as temporary head of Colonel Grant's reserach organization. Now he was taking over the Research Division of the School, to perform the same feat for the institution at Randolph that he had accomplished at Wright Field half a dozen years ago.

Less than two weeks after Armstrong's arrival, Lieutenant Colonel Fabian L. Pratt wound up his tour as commander of the School and departed for Hamilton Field, California. The flight surgeon who succeeded him the next day was Lieutenant Colonel Eugen Gottfried Reinartz, who had spent several years at the School in the early nineteen-thirties as director of Neuropsychiatry.

Eugen Reinartz, born in East Liverpool, Ohio, was the son of a Lutheran minister from Dusseldorf, Germany.[9] He had studied medicine in Philadelphia, taking his degree in the summer of 1916, when he was 26 years old. The United States had entered World War I while he was completing his internship at Philadelphia General Hospital. Three months later, Doctor Reinartz had joined the Army Medical Corps. For the duration of the War he had been assigned as a surgeon at Vancouver Barracks in Oregon.

After the War, Reinartz had gone to Wright Field, and there his interest had been captured by the little-known problems of men whose occupation was to guide vehicles through the air. Accepted for training by the School of Aviation Medicine, he had been the honor graduate of his class at Mitchel Field in September 1920.

Since then, Doctor Reinartz had served with distinction as a flight surgeon in California and the Philippines; had taken a residency in psychiatry at St. Elizabeth's Hospital in Washington, D. C.; had commanded Army hospitals at Wright Field and Chanute Field; and had been the assistant departmental surgeon in Hawaii as well as the first flight surgeon at Hickam Field. He was known as a medical officer combining a high degree of professional knowledge and insight with exceptional administrative ability.

In little more than a year after his arrival at Randolph, Doctor Reinartz would become the first brigadier general to command the

School. He was to guide it through the period of its vast expansion, until after the end of World War II. He would visit the war zones in England and North Africa, but would end his career without ever having been assigned to one. For his service to research in aviation medicine, he would receive the John Jeffries Award from the Institute of the Aeronautical Sciences and twice would be elected President of the Aero Medical Association. Though younger men were to shape the ultimate character of the practice he had chosen, General Reinartz would bring much honor to his profession and would receive much honor from it.

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Chapter 10

AFTER PEARL HARBOR

Early in the morning of December 7, 1941, a dozen B-17 bombers flew in out of the east over the island of Oahu, after a night flight across the Pacific from California.[1] Their guns were sheathed in a protective coating, they had no ammunition, and much of their armor plate had been removed so that they could carry more fuel. They were on their way to reinforce the Air Corps squadrons in the Philippines.

Aboard one of the Flying Fortresses as a passenger was a young Army medical officer, released from the course at the School of Aviation Medicine eleven days before, with orders assigning him to Hickam Field in Hawaii. Lieutenant William Rhinehart Schick was a native of Chicago. He had studied medicine at the University of Illinois, taking his degree in 1939, and had completed his internship a year later at Evangelical Hospital.

After less than a year in practice, Doctor Schick had been called to active duty with the Air Corps and sent to Randolph Field for training. He was to have been graduated with his class on December 14. But there was an urgent need for flight surgeons in air units bound for the Pacific to strengthen American forces during the crisis in the Far East. So Doctor Schick had been withdrawn from the course three weeks early, with full credit, and ordered to Hawaii. He was 31 years old.

After a short visit with his family in Clinton, Iowa, Doctor Schick had joined the flight of B-17s on the West Coast, in time for the takeoff across the wide expanse of slate-blue ocean. When they sighted the peaks rising up on the horizon before them, a little after dawn, the crew congratulated themselves on a routine crossing. Then they saw the smoke towering above Pearl Harbor,

and heard the incomprehensible noises on the radio. As they glided down toward the green hills beyond the beaches, they were enveloped in a swarm of alien aircraft, diving on the installations below.

The Japanese pilots in World War II were noted for the tenacity with which they followed the flight plans assigned to them, ignoring any unexpected targets, no matter how tempting. Aside from a few casual fighter passes, they paid little attention to the bombers coming in from the sea. As the Fortresses scattered, searching for any safe field on which to land, three were heavily damaged, but made it to the ground intact. One was shot down and destroyed. That was the craft in which Lieutenant Schick was riding. He was the first flight surgeon ever killed in action with an enemy.

Before the War was over, there would be seven more.[2] In order, they were Captain Charles A. Stafford, in Java; Captain George C. Wassell, in the British Isles; Captain Joseph W. Mendoza, in Newfoundland; Lieutenant Burton A. Hall, in New Caledonia; Major John J. Meany, in North Africa; Lieutenant William C. Craig, in Ireland; and Major Barney Lihn, in France. With the 44 who would have died in airplane accidents by V-J Day, they were to bring the names of flight surgeons on the Honor Roll of the School at Randolph to 52.

After Pearl Harbor, the War lost its tidy character as a continental campaign for control of Europe. It became a collection of many local campaigns in widely separated places, not always with the same participants. There was a war in China, another in Southeast Asia and its adjacent islands, one in the isolated atolls of the Pacific. There were wars in Africa, in the Balkans, in the Baltic states, and later on the wide plains of Russia. There were naval wars in the Atlantic, in the North Sea, in the Mediterranean, in the Pacific. In time there was a war in Italy, and at last a renewal of the war in France. All were related in their effect on the final issue, but sometimes by threads so tenuous that the connection could not be clearly seen until afterwards, when the outcome was almost at hand.

For the School of Aviation Medicine, as for other institutions on the home front, these actions occurred at a great distance, in no logical succession, against a changing background, like episodes

in a news reel. Both in its classes and in its laboratories, the School was alert to conditions in the different parts of the world where Americans were—or might be—engaged. The staff received detailed reports and directives, forwarded from Headquarters in Washington. Medical officers returning from the various theatres lectured on the problems they had met or observed.

But most of the time, for the next four years, the School was occupied with an unremitting campaign of its own, to keep pace with the demands of all the remote regions where the fighting was. Its contribution to the War was a tenacious effort to provide competent flight physicians and assistants where they were needed, armed with informed answers to all the bewildering variety of questions that could be asked of them.

In research, as in teaching, the effort already was under way at the time of the disaster in Hawaii.[3] Shortly after his arrival, Major Armstrong had written to the deans of all the accredited colleges of medicine in the United States, asking them to recommend qualified physicians and biologists who might be interested in applying for research positions at Randolph. Those who were selected would receive appointments in the Civil Service. Later, if they were eligible, they would be offered Reserve commissions in the Air Corps.

The response to this letter was a tidal wave of applications, most of them forwarded within a week or so after the attack on Pearl Harbor and the declaration of war with Japan and Germany. It took Doctor Armstrong another month to sift through the answers, weighing the professional records and attainments of the applicants.

Meanwhile, in January, he formed the nucleus of his research planning staff. Besides Major Arthur W. Melton, the psychologist whom he had brought with him from Washington, it included two instructors lifted out of the Training Division. Major Paul A. Campbell was an ear-and-throat specialist from Chicago, called to active duty with the School a year earlier, while Captain Melvin W. Thorner was a talented neuropsychiatrist. A young physician recently commissioned, Lieutenant Herman S. Wigodsky, was in charge of physiology. Captain Loyd Stevens was an administrative assistant to the Director.

The first low-pressure chamber seen at the School since 1926 arrived in January too. Neither so large nor so elaborate as the one built for the Laboratory at Wright Field, it was a horizontal cylinder with an air-lock inside the entrance at one end, roomy enough for experiments or training sessions involving as many as a dozen men with their equipment. It was installed in a temporary building next to the Hospital.

In February, Doctor Armstrong finally set out on a trip around the country to interview a hundred or so of the applicants who had been recommended for assignments in research. From this recruiting expedition came the marrow of the School's research organization during the War, consisting of both officers and civilians. Among the first to be commissioned were Francis C. Keil Jr., M.D., an ophthalmologist; Allan Hemingway, Ph.D., a biophysicist; and Jack Buel, Ph.D., a psychologist.

Some of the outstanding civilians who served to the end of the War were William Rowland, M.D., and his wife, Louise Sloan Rowland, M.D., both ophthalmologists; Peter Vasily Karpovich, M.D., a specialist in physical fitness, who had been a medical officer with the Russian Army in World War I; John S. Gray, Ph.D., a physiologist; and Roger B. Loucks, Ph.D., a psychologist.

Other specialists added to the staff, like Charles E. Kossmann, M.D., a cardiologist, and later Jan H. Tillisch, M.D., of the Mayo Clinic, already were officers of the Medical Reserve Corps. Together with the Regular medical officers who were assigned to the School from time to time during the War, they gave the new Research Division an exceptionally strong capability in experimental medicine and its related sciences.

Toward the end of February, Doctor Armstrong was promoted to Lieutenant Colonel. Early in March, the Air Corps was promoted too.[4] It became the Army Air Forces, one of only three equal and autonomous commands under the War Department. (The others were the Ground Forces and the Services of Supply.) The former Chief of the Air Corps, General Henry H. Arnold, now was the Commanding General of the Air Forces and a member of the Joint Chiefs of Staff. Major General David Grant became the Air Surgeon.

The change in status only recognized the power and strategic importance that aviation had shown by its influence on events in the early campaigns of the War. Nevertheless, its recognition simplified the problems of command and administration in an air organization which was bringing its strength to bear on every combat theatre around the globe. For the School of Aviation Medicine, it made people and funds, buildings and equipment, easier to come by. Once again, the School dealt directly with the Air Surgeon.

Through March and April, architectural planning went ahead on the new Research Building. Meanwhile, room was found for the laboratories in the original School Building and in some of the temporary barracks-style structures which had begun to rise on odd bits of land around the School and the Hospital.

The difficulty of making space both for expanding classes and for expanding laboratories had eased somewhat since February, when the School had been directed to adopt a new teaching system proposed by Doctor Armstrong.[5] Three branch schools had been opened in the Aviation Cadet Centers at Maxwell Field, at Kelly Field, and at Santa Ana Army Air Base. (The branch at Maxwell later moved to the Army Air Center in Nashville, Tennessee.)

The course for aviation medical examiners was lengthened to three months again, and was divided into two parts of six weeks each. The first half consisted of academic instruction, given at Randolph. The second half was devoted to practical experience, under the supervision of flight surgeons at the Centers.

The branch schools were to last a mere twenty months. Then the course would be reduced to nine weeks, and all of it would be given at Randolph once more. By that time, the laboratories would have a permanent building of their own, while space in temporary class rooms would be ample for the teaching function.

Harry Armstrong was not to see the opening of his second Research Laboratory. Early in May 1942, after eight months at Randolph, he received orders reassigning him to England.[6] His friend and collaborator, Malcolm Grow, now was Surgeon of the Eighth Air Force. Armstrong was to be his assistant until the spring of 1944, when Grow would move on to Supreme Headquarters, Allied Air Forces, and Armstrong would succeed him as Eighth Air Force Surgeon for the duration of the War in Europe.

As the ranking physician in the Research Division, Major Campbell became the Director. Then 39, Paul Campbell had a professional background of considerable distinction. A native of Indiana, he had studied medicine at the University of Chicago, taking his degree from Rush Medical College in 1928. Immediately after his internship, he had joined the Medical Reserve Corps of the Army.

For four years in the early nineteen-thirties, Doctor Campbell had served as chief of the medical staff at Culver Military Academy, in his home state of Indiana. He had then gone abroad for a year of postgraduate study at the University of Vienna. Since 1938, he had practiced as an otolaryngologist in Chicago. Besides, he had taught at Rush, at the University of Illinois, and at Northwestern University.

In the spring of 1940, Doctor Campbell had completed the course in aviation medicine at Randolph, qualifying as a flight surgeon. A few months afterwards, he had been called back to serve on the teaching staff. Now he was to carry on the work that Doctor Armstrong had started, guiding the Research Division until the close of the European War.

While Colonel Armstrong was on his way to England, Washington approved the architect's plans for the Research Building. Early in June, the foundation was staked out on an open field that had been a parade ground, two blocks north of the School Building on the Main Circle. By October, the shell was up. On January 1, 1943, the laboratories began to move in. On February 27, the building was accepted.

Of hollow tile and white stucco, it was nearly the size of the School Building and rather more stately in appearance. The entrance was recessed inside a high, arched portico, and blazoned with the crest of the School in color above the door. Inside, the stairs were of polished terrazzo. The halls were wide, with fluorescent lights, and the entire building was air-conditioned.

One of the first occupants was General Reinartz. Perhaps to symbolize the renewed importance of research, he moved his executive offices into a wing on the second flood, where he was surrounded by the Director of Research and by Research Administration. Down the hall was the Library, and beyond that, at the end of the other wing, was a spacious conference room for meetings with the staff or with visiting dignitaries.

Most of the working laboratories were below, on the ground floor or in the basement, where the low-pressure chambers were. Two of these were much enlarged and improved versions of the horizontal chamber hastily assembled the year before, each with an air-lock inside the entrance and with panels containing multiple thicknesses of glass through which to observ subjects. One had a normal capacity of sixteen men; the · accomodated twenty men and was equipped with refrigera ion besides. In addition, there were three small upright chambers for specialized experiments with laboratory animals.

Supplementing the pressure chambers was an environmental weather room, in which climatic conditions such as miniature snow storms could be produced, to observe their effects on the performance of men and equipment. With these and other pieces of advanced instrumentation, the School once again possessed facilities for research in aviation medicine that could be duplicated nowhere else.

The Research Laboratories were formally opened at the beginning of April, in a three-day celebration marking the twenty-fifth anniversary of the School. The guests included General Henry H. Arnold, commanding the Army Air Forces, half a dozen ranking generals of the Flying Training Command, the Surgeons General of the Army and the Navy, and the Air Surgeon, General Grant.

Among the surviving members of the original Laboratory at Hazelhurst, on hand for the celebration, were Colonel Isaac Hampshur Jones, Colonel Eugene R. Lewis, and Colonel Edward C. Schneider, all summoned from retirement for the occasion; Lieutenant Commander Robert J. Hunter, who had been the first Army flight surgeon to report for duty in 1918 and now was serving in the Navy; and Major Harold F. Pierce, the young physiologist and engineer, who had since become a medical officer. Their host was Lieutenant Colonel W. Harvey Kernan, the former Adjutant, who now was the Executive Officer of the School.

A stained-glass window in the Chapel at Randolph, donated by students of the class for medical examiners, was dedicated to the memory of deceased flight surgeons. Colonel Isaac Jones made the School a gift of a historical film bearing the title, *Fit to Fly*, produced at the Laboratory in 1918. (Later it was deposited in

the film archives of the National Museum in Washington.) General Reinartz dedicated the new building, while Doctor Campbell gave the key to Colonel Kernan, who opened it. After a sumptuous banquet at the Officers' Club, the visitors departed and the School went on with its work.

During World War II, the research studies carried on at Randolph rarely had the spectacular quality—the effect of ranging far beyond previous boundaries in the sky—that had characterized the early investigations of Schneider and his colleagues at Hazelhurst. It was not to be expected that they would. Aviation now was an established service, with an intricate organization reaching around the world, bearing a large part of the strategic, tactical, and logistic burdens of the War. Its ordinary operations were beset with technical and human problems of an often humdrum variety. The search for practical answers to these problems took precedence over exploration in the loftier regions of the atmosphere.

As with most wars, it was fought mainly with the weapons which were ready for production when it began.[7] The first experimental jet aircraft was tested by the German Luftwaffe as early as August 1939. It was not flown in combat until the last year of the War. The rocket-propelled V-2 missile appeared over London at about the same time, in relatively small numbers. American bomber forces in Europe relied on the B-17 and its companion, the B-24, until the fighting ended. When the pressurized B-29 was finally deployed, it went to the Pacific for the last massive strikes against Japan.

The research tasks laid before the School, then, more often than not were in traditional areas of medicine, although they were none the less important for that reason.[8] In otolaryngology, for example, they were concerned with common inflammations of the ear and sinuses, and particularly those which were caused or aggravated by pressure changes in flight. The effects of aircraft noise on hearing were investigated, and new auditory standards were developed. Research in ophthalmology focussed on such questions as color perception, night vision, and the influence of altitude, intense light, or drugs on visual acuity.

Pharmacology gave its attention to new antibiotics and antimalaria preparations, widely distributed for the first time during the War; to the cause and prevention of airsickness in flyers; to

the effects of carbon monoxide in aircraft. Physiology studied the mechanisms of decompression sickness, especially with rapid losses of pressure. Much of its time, too, was spent in testing new oxygen masks and related equipment, forwarded from Wright Field for evaluation.

Pathology investigated injuries resulting from aircraft accidents, particularly from the viewpoint of structural designs and body positions that might contribute to the severity of the injuries. The possibility was considered that dynamic forces in an airplane out of control might often hinder a normal escape by parachute. The use of an automatic ejection seat in future aircraft was discussed.

To handle the wide range of questions passed on to the School by the Air Surgeon's office, more research departments had been organized. From six at the beginning, they had now grown to thirteen. The most recent additions were Military Medicine and Tropical Medicine (later called Global Medicine, and in time known simply as Preventive Medicine).

In fact, the proliferation of separate departments for research and teaching had become a hindrance to the total effort of the School. It raised difficulties in securing enough qualified people to staff them all. More especially, it hampered the ready flow of new knowledge and techniques, uncovered by research, to the student medical officers who would soon be asked to put them into practice in the combat theatres overseas.

So in January 1944 the structure of the School was revised again.[9] The duplicate departments were combined, while teaching duties were distributed among the research staff. The Directors of Research and Training—Lieutenant Colonel Campbell and Colonel Victor A. Byrnes—continued to administer their separate programs within the departments.

Then another activity altogether was added to these programs. In October 1944, the Army Air Forces School of Air Evacuation was transferred to Randolph from Bowman Field in Louisville, Kentucky.[10] It was incorporated into the School of Aviation Medicine as the Division of Air Evacuation Training.

Air Evacuation of battle casualties was the application of a belief expounded by medical officers ever since World War I—that the swiftest way to remove the sick and wounded from combat areas, with the least distress for the patients, was by air. In the spring of 1941, the Air Surgeon had asked for authority to form a flying battalion of litter transports manned by flight surgeons, nurses, and medical technicians. Two weeks before the assault on Pearl Harbor, the authority had been granted.

Later on, the plan had been expanded to permit regular cargo aircraft of the Troop Carrier Command, returning from the war fronts, to transport patients under the care and supervision of air-evacuation squadrons. Three squadrons had begun their training at Bowman Field in November 1942. On Christmas Day, the first of the three had taken off for North Africa.

Out of this program had evolved a concept as novel in its way as the idea of the flight surgeon in 1917. It was the realization that a young woman capable of watching over a planeload of litter patients in flight—and of helping them to escape and survive, if necessary, in an emergency—needed more than the qualifications of a graduate nurse, or even of an officer with military training. Her position as an active member of the crew was more nearly comparable to that of an airline hostess—or of the flight surgeon himself.

To make the distinction more evident, the Air Surgeon had devised a new aeronautical designation: the Flight Nurse. Her special qualifications as a crew member were marked by wings resembling the ones worn by flight surgeons. The first group of nurses to receive them had been graduated by the School of Air Evacuation in February 1943. Since then, a total of 1,079 flight nurses had gone out to the fighting fronts with aeromedical squadrons. One of them—Lieutenant Ruth Gardiner—had been shot down over Alaska the next July. Before the end of the War, seventeen in all would be killed in action from Germany to the Philippines.

The patient-airlift school was transferred to Randolph so that it could share in the increasing stores of knowledge and experience accumulated by the School of Aviation Medicine. It brought with it a small staff of sixteen flight surgeons, flight nurses, and administrative officers, headed by its former Commandant, Colonel John R. McGraw. Colonel McGraw became the acting assistant

to the Commander, General Reinartz, while the additional courses for flight nurses and technicians were being absorbed into the teaching program. The rest were assigned to the newly organized departments of Air Evacuation and Nursing.

Only three months later, in January 1945, the School of Aviation Medicine fell heir to still another activity—this time one which was not so readily fitted into its existing services. After a visit from the Air Surgeon, the base commander at Randolph was persuaded to turn over operation of the 250-bed Station Hospital to the School.[11]

Actually, it was General Reinartz who had first conceived the idea that the School should have a hospital of its own. Three years before, he had suggested that a new 500-bed hospital should be built for the School, at or near Randolph, as a clinical aid in teaching, as an adjunct to research, and as a treatment center for obscure or difficult conditions related to flying. The General's thought had been that the new hospital would be entirely separate from the base facility, handling cases of a highly specialized type, referred from operational units of the Army Air Forces wherever they were dispersed about the world.

Nothing had come of this proposal at the time, but the Air Surgeon had remembered it. When the shortage of experienced medical officers had grown acute in the later stages of the War, he had thought of consolidating the smaller Station Hospital with the School as a first step toward the founding of an aviation medical center at Randolph.

To manage its new property, the School organized a Division of Hospitalization under the Surgeon then in charge of the Hospital, Colonel Merrill J. Reeh, as Director. The eleven medical officers on Colonel Reeh's staff were distributed among the clinical departments; the sixteen ward nurses were added to the Department of Nursing. It now became the duty of all qualified medical officers at the School to make themselves available for practice and consultation, as well as to teach and to conduct research.

On May 7, 1945, the War in Europe ended abruptly with the surrender of Germany. On August 6, in the Far East, the first nuclear bomb in the history of human warfare was touched off over the city of Hiroshima. Eight days afterwards, just as abruptly, Japan surrendered. World War II was over.

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Chapter 11

CHANGES IN DIRECTION

In the spring of 1946, after four years with the Air Forces in Europe, Harry Armstrong returned to his point of departure, the School of Aviation Medicine.[1] His homecoming at Randolph might have struck Colonel Armstrong as an anticlimax, but for one significant change in the circumstances. He was not resuming his old position as Director of Research. Instead, he was to be the new commander, relieving General Reinartz.

As usual, he arrived by a somewhat roundabout route. From the Eighth Air Force in England, a few weeks after the surrender of Germany a year earlier, he had gone to the Office of Military Government in Berlin as Surgeon for the Armed Forces. There, one of his tasks had been to assist in a project undertaken by Brigadier General Malcolm Grow, Surgeon of the United States Strategic Air Forces in Europe.

Since World War I, Germany had regained much of its former leadership in science and technology, notably in such fields as aeronautics, which were vital to rearmament.[2] The Luftwaffe had sponsored a number of laboratories for research in aviation medicine, staffed by civilian scientists. Among the most prominent were the Aeromedical Research Institute in Berlin, conducting basic studies comparable to those carried on in America by the School at Randolph, and the Institute for Flight Physiology in Rechlin, a counterpart of the medical engineering Laboratory at Wright Field.

During the last weeks of World War II, as the Soviet and American armies had closed in from the east and from the west, virtually all of the laboratories and test facilities associated with the German war effort had been abandoned, and their civilian staffs had dropped out of sight. Both the Russians and the

Americans, in their respective occupation zones, were anxious to find the missing scientists, in order to question them about the results which they had obtained from their studies.

In Washington, the Air Staff had hastily assembled a team of fifty or so military and civilian authorities on aeronautical science, including aviation medicine, and had dispatched them to London. One of the half-dozen members of the medical group was Detlev W. Bronk, Ph.D., consultant on research to the Air Surgeon. Another was Colonel Paul Campbell, who had replaced Colonel Armstrong as Director of Research at Randolph three years earlier.

At a military prison on the outskirts of London, they had interviewed Major General Oskar Schröder, Surgeon General of the Luftwaffe, and his staff. Armed with a list of eminent German specialists in various aspects of flight medicine, they had gone on to Berlin. There, Colonel Armstrong had put the resources of his office at their disposal, while they dispersed over the American-occupied sector of Germany in search of the lost scientists.

By August, they had turned up sixty or more outstanding figures in wartime research for the Luftwaffe. The most illustrious was a 47-year-old professor of physiology, Hubertus Strughold, M.D., who had been the Director of the Aeromedical Research Institute in Berlin. With Siegfried Ruff, M.D., of the Institute for Flight Physiology, Doctor Strughold was the author of a German text on aviation medicine, *Grundriss der Luftfahrtmedizin*.[3] Many of the younger specialists had been members of his research staff.

At the Kaiser Wilhelm Institute in Heidelberg, General Grow had established an American research center.[4] There, under the direction of Colonel Robert J. Benford, the German specialists were employed for the next eighteen months, writing a comprehensive report on German aviation medicine in World War II. Translated into English and assembled at the School of Aviation Medicine, it was later published in two large volumes by the United States Air Force.

Meanwhile, at the end of 1945, Harry Armstrong had been summoned back from Berlin to the office of the Air Surgeon in Washington.[5] The Congress, the Armed Forces, the press, and the public

had turned their attention away from their late enemies abroad for the time being, to consider the future organization of the American military services. Out of World War II had come the realization that the United States could not simply call home the fighting men it had dispersed around the world, reduce them to a token force, and retire within its own borders again, as it had done after World War I. A permanent defense establishment on an unprecedented scale would be needed thereafter, to preserve the peace that had been won at so much cost.

It was generally agreed that the uniformed services should be consolidated into a single department of defense, under one civilian head, with specialized branches for the ground, sea, and air components. The question on which the services and their adherents were divided was how much freedom of action the branches were to have—whether, for example, they should take orders from a General Staff, modeled on the European system, or whether they should serve under the operational direction of their own commanders. This question was to be debated for the next year and a half before a compromise was found.

Each of the services, in the mean time, had to plan its organization and activities for the postwar era in accordance with the probable outcome of the debate, under the greatly reduced budgets that followed the end of the fighting. For the air arm—still a semi-autonomous branch of the Army—this meant the creation of a new administrative structure to fit its peculiar operational needs, founded on the diverse properties and institutions which it would inherit from its parent. Fortunately, the Army and the Air Forces were more or less united in their views, against the opposition of the Navy.

The Air Surgeon, General Grant, had sent for Colonel Armstrong to acquaint him with the plans which were in the making for the Air Force medical department, and particularly for the School of Aviation Medicine. General Grant's belief was that the School should be the doctrinal center of the Air Force in evolving, teaching, and prescribing the application of the techniques of flight medicine. In its own field, it would be comparable to the Air War College in defining strategy. As the next commander, Colonel Armstrong was expected to formulate programs which would foresee and support the future operations of the Air Force.

After two months in Washington, Colonel Armstrong went on to Randolph, arriving in March. On April 1, the opening move in General Grant's plan of reorganization took effect.[6] The School was detached from the Air Training Command, with which it had been intimately associated for the past twenty years. Although it remained at Randolph, it was placed under the authority of the Air University, just then in the process of being formed at Maxwell Field, in Montgomery, Alabama.

The Air University itself embodied a new concept in military organizations. Patterned after a civilian university, it was designed to oversee the professional education of Air Force officers, as distinguished from the technical skills which they were taught by the Air Training Command. Its major units were the Air War College, the Air Command and Staff School, and the Air Force Institute of Technology. It provided for graduate studies by officers with talent in scientific fields. Its Library was a prime source for research materials in aeronautics. The School of Aviation Medicine became its postgraduate medical college.

The benefit of this change to the School was mainly in its professional climate and standing. No longer considered as a practical facility, whose immediate function was to assist in the care and training of air cadets, it was now among people whose outlook on the basic value of learning was similar to its own. Hereafter, it could concentrate wholeheartedly on the three aims for which it had been founded—exploring new medical prospects in the flight environment, passing on its knowledge to physicians, nurses, and others who were directly concerned with the human problems of flying, and offering a specialized clinical service in exceptional cases which were outside the experience of base medical officers.

Another result of the change was to relieve the School of responsibility for the Hospital.[7] The commanding officer at Randolph naturally disliked the idea that patients in the Hospital would be transferred out of his jurisdiction altogether, into another major air command. For the sake of administrative efficiency, he felt that all the local medical facilities on the base ought to be under the supervision of the Post Surgeon. General Grant saw the logic of this view. On May 1, after only sixteen months as a branch of the School, the Hospital was returned to its old management, along with its clinical staff.

The fact was that the Hospital had been ill suited to the purpose for which it was given to the School in the first place. General Reinartz had thought of it as a teaching facility, as an adjunct to research, and as a clinic where unusual cases could be studied. But the Hospital normally was used to its full capacity for the care of patients with routine medical conditions among the military men and their families at Randolph. Instead of adding another dimension to the practice of aviation medicine, it had been a means of diverting the specialized talents in the School from the work for which t. y had been chosen and trained.

So the next commander would have to look elsewhere for a clinical element to round out the competence of the School in its own field. But the lack of a suitable treatment facility was not the only difficulty the School faced, nor even the most urgent. In the last four years, it had grown so large that Randolph no longer had room for it. Its two fine permanent buildings masked a collection of makeshift structures in which most of its activities were housed.

During its rapid wartime expansion, the School had spilled over into 57 miscellaneous shelters, scattered about the southwest corner of the base.[8] They included nearly all its class rooms, a number of laboratories, administrative offices, barracks for its students, warehouses, and shops. They were so dispersed that it was a task to find many of them, let alone to coördinate their operations by any coherent plan. No space was left at Randolph for a group of permanent buildings which would bring most of these functions together.

At the moment, they were not so crowded as they had been a few months earlier. With the end of the fighting overseas, the same urge that had swept the School in 1918 had seized much of its professional and technical staff again—to resume careers in research, teaching, or practice which the War had interrupted. Almost to a man, the civilian specialists recruited after Pearl Harbor had returned to the universities from which they were on leave. So had nearly all the Reserve officers on active duty. The enlisted technicians had gone back to college for advanced degrees or to jobs in commercial laboratories.

By the summer of 1946, the total roster of the School had dropped from 557 at its wartime peak to 242. Many of the research laboratories were reduced to one or two relatively junior

medical officers of the Regular Army. Much of the new equipment was idle. With the rest of the great military and industrial establishment created by the War, the School was waiting to discover what its place would be in the altered world created by the peace.

One of the immediate tasks facing Colonel Armstrong was to rebuild the professional staff—not necessarily to its inflated wartime figure, but to a point where it could make full use of the elaborate physical plant which it had now acquired. In the process, he would find it necessary to change the fundamental character of the School as it had existed up to the outbreak of the War. From a specialized military organization, manned by a small group of flight surgeons, it was to be transformed into an experimental institute composed largely of civilian scientists, with a judicious mixture of medical officers providing overall direction to its inquiries.

Nor was the reconstitution of the staff all that Colonel Armstrong had in mind. He was evolving a plan which would detach the School entirely from its improvised quarters at Randolph, and remove it to another site matching the enlarged scope of its operation. An essential feature of the new setting would be a clinical branch of its own. Like the Air University as a whole, it was conceived not merely as an academy for postgraduate studies, but as a doctrinal center of the arts and sciences encompassed in flight medicine.

It was to develop this plan that Harry Armstrong had come to Randolph several months before he was expected to relieve General Reinartz. Without any specified duties in the mean time, he had been free to gain a fresh view of the School and its resources, to formulate his ideas, and to assemble facts to support them. Now he was ready to make a formal recommendation to Air University and to Washington.

On July 18, 1946, Eugen Reinartz handed over the School of Aviation Medicine to his successor, and went off to begin his retirement.[9] It was to be an exceedingly active retirement. Later in the year, Doctor Reinartz opened an office in San Francisco as a practicing psychiatrist and consultant in aviation medicine. Two years later, he was to be appointed chief medical officer of

the California State Prison at Soledad, in the mountains west of Monterey. He would hold that office until he was ready to retire again, in 1955, to a sunny home in Carmel Valley. After a dozen more years, he would still be traveling across the continent to meetings as he approached his seventy-eighth birthday.

Colonel Armstrong spent his first two weeks as commander of the School putting his project for a more versatile institution into the form of an official proposal.[10] On August 3, 1946, he dispatched it to Air University Headquarters under the title, "An Army Air Force Medical Center." Basing his justification on the need for a diagnostic, research, and teaching center devoted specifically to the medical problems of flyers, he cited the inadequacy of the existing facilities at Randolph and recommended that a new complex be established at another site. The cost was estimated at $28,000,000.

This project came to be known as the Aeromedical Center. It was received with enthusiasm by the Air University commander, and forwarded with his endorsement to the office of the Air Surgeon in Washington. There, as it happened, General Grant was winding up his term, which already had lasted for five years. The next Air Surgeon was to be Major General Malcolm Grow, returning for the second time to the position which he had first held eleven years before.

Armstrong's proposal was turned over to General Grow in November, shortly after he returned from Europe. General Grow added some reflections of his own, and sent it on to the Commanding General of the Army Air Forces. The Commanding General gave it to the Air Staff for study. The Air Staff approved it—emphatically in the case of Major General Frederick L. Anderson, Major General Curtis E. Le May, and Major General Edward M. Powers. Then it was laid aside, to await the outcome of the debate in Congress over the future status of the Air Force.

While the Aeromedical Center was in abeyance, General Grow was able to give Colonel Armstrong some unexpected help with another problem—rebuilding the professional staff of the School. Before he left Europe, Grow had joined with other American military and civil leaders in a program which set a new precedent in relations between a victorious nation and a defeated enemy.

It was to offer employment in the United States to gifted German scientists who were cleared of any complicity in the political and ethnological excesses of the Third Reich.

The research laboratories founded by the Luftwaffe—like the rocket development and test facilities at Peenemünde—had been dismantled. The German aviation industry was destroyed. The universities could absorb only a handful of the scientists. The American center at Heidelberg had now completed its work, except to finish translating the papers contributed by its German associates and to edit them for publication. With the closing of the center, there would be nowhere in their own country that most of these authorities could apply their knowledge of the new techniques in aviation medicine.

But the American Army—and particularly its air arm—had an urgent need for minds familiar with these very techniques. Even while its future command and structure were being argued in Washington, the Air Force was making the transition from propeller-driven planes to jets, operating at higher altitudes and at much greater speeds. At the White Sands Proving Ground, in New Mexico, Army Ordnance was experimenting with rocket engines, using V-2 missiles captured from the Germans. At Rogers Dry Lake, California, in the Mojave Desert north of Los Angeles, both the Army and the Navy were developing aircraft powered by rockets. They would travel far higher than jets, at speeds beyond any that human beings had experienced before.

The scientists were invited to enter into five-year contracts, under which they would carry on their studies at government agencies in the United States.[11] They would travel under military orders, as other civilian employees of the Armed Forces did, and would receive special entry permits, granting them the protection of the State Department until diplomatic relations were resumed with Germany. Their families were to join them as soon as they were established in their new homes.

The physicists and engineers who had been with Dr. Wernher von Braun at Peenemünde accepted this offer with alacrity and joined him at the White Sands Proving Ground. The medical specialists were somewhat more reluctant, possibly because they were steeped in the academic tradition of German science. But in the end they signed their contracts, and sailed from Bremen

for the United States. Some were assigned to the Aero Medical Laboratory at Wright Field or to the Navy School of Aviation Medicine at Pensacola. The largest single group went to the School at Randolph.

As they arrived, beginning in January 1947, Doctor Armstrong made them welcome, found temporary quarters for them at the base, and appointed them to vacant positions on the staff. Among the first departments to feel the fresh influx of talent was Physiology, now combined with Biophysics. Three of its additions were to become figures of distinction in American research.

Hans-Georg Clamann, M.D., came from the Aeromedical Institute in Berlin, where he had been Doctor Strughold's deputy director. His wide range of interests included the mechanisms of gas exchange in respiration and the effects of oxygen in various concentrations.

Ulrich Cameron Luft, M.D., half German and half Scot, had been educated both in Edinburgh and in Berlin, his home. As chief of respiratory physiology at the Berlin Institute, he had focused his attention on problems of pressurization and pressure loss at high altitudes. Several of his papers were included in *German Aviation Medicine, World War II.*

Bruno Balke, M.D., was a mountain physiologist who had served as a medical officer with the German Army. His particular concern was with adaptation and performance at high altitudes.

Ophthalmology received two notable accretions, both from the Institute in Berlin. Heinrich W. Rose, M.D., had been a flight surgeon in the Luftwaffe. His special areas were visual acuity, night vision, and depth perception—particularly the possibility of monocular depth perception, when one of the flyer's eyes was incapacitated. Ingeborg Schmidt, M.D. the daughter of a Baltic German family in Estonia, was internationally recognized as an authority on color vision. Both were contributors to the work on German aviation medicine.

Neuropsychiatry was bolstered by the appointment of Werner K. Noell, M.D., a specialist in electroencephalography from the Institute of Brain Research at Göttingen. Otolaryngology acquired

Jürgen Tonndorf, M.D., from the University Hospital in Heidelberg. Doctor Tonndorf had been a Navy surgeon with the Submarine Service during the War.

Several other physicians were to join this group later. Among them were Bernhard Hölscher, M.D., in Physiology; Paul Cibis, M.D., in Radiobiology; and a pair of neurologists, Abraham G. A. Bingel, M.D., and Richard Lindenberg, M.D.

They were accompanied, too, by a handful of physical scientists who had been associated with research in aviation medicine. These included Konrad J. K. Buettner, Ph.D., a meteorologist specializing in the biological effects of atmospheric and climatic conditions; Heinz Haber, Ph.D., an astrophysicist, whose interest was in the human effects of forces such as gravitation; his brother, Fritz Haber, D. Eng., an aerodynamic engineer; and Oskar L. Ritter, Ph.D., a mathematician and physicist.

In much the same situation was Siegfried J. Gerathewohl, Ph.D., a psychologist. As an officer in the Luftwaffe at the start of the War, he had managed the selection test program for an aviation cadet center at Hamburg. Since then, he had turned his attention to the psychophysiological functions of information-sensing organs like the eye. Doctor Gerathewohl also had been trained as a glider pilot.

Conspicuously missing from this roster was the name most widely associated with aviation medicine in Germany: Hubertus Strughold. Doctor Strughold had just been appointed Professor of Physiology and Director of the Physiological Institute at the University of Heidelberg. He was lecturing to students again for the first time since the War had interrupted his classes at the University of Berlin, and looking forward to a long career as an honored member of the academic community. Much as he was drawn toward the flight research which had been restored to life and health in America, he could not bring himself at the moment to leave Heidelberg.

Meanwhile, the American center at Heidelberg was closed on March 15, 1947. Its three German translators (one of them a sister of Doctor Ingeborg Schmidt) were added to the colony at Randolph Field. There they went ahead with the task of editing *German Aviation Medicine, World War II.*

A few weeks after they arrived, the future of the air arm was at last decided.[12] On July 26, President Harry Truman signed the National Security Act of 1947, setting up separate military departments for the Army, the Navy, and the Air Force, within a common Department of Defense. Each of the uniformed branches was to have its own civilian Secretary and its own operational command structure. Each was to be represented on the Joint Chiefs of Staff. The first Secretary of the Air Force was to be Stuart Symington, the former Assistant Secretary of War for Air. The first Chief of Staff was General Carl Spaatz.

But the Act creating the Air Force omitted one essential provision. It failed to specify that the flying branch was to have its own medical service. So another long-drawn-out controversy arose over the question whether the armed forces as a whole should combine their medical departments into a single professional organization or whether each ought to maintain a separate corps of specialists to deal with its peculiar health problems.

The controversy was to linger on for another eighteen months or more, and was to subside only when Secretary of Defense Louis Johnson issued an order to the Army, directing that it turn over to the Air Force that part of its medical staff and facilities which was primarily in support of aviation. The transfer was to take effect on July 1, 1949.

In the mean time, the School of Aviation Medicine found itself in an odd situation. As an operating element of the Air University, it had now become a physical property of the Air Force. But its medical officers and corpsmen still were members of the Army, subject to Army orders. The School received its professional guidance from General Grow, who functioned as a member of the Headquarters staff of the Air Force but was in fact the Air Surgeon of the Army.

One result of this confusion was to prolong the delay in proceeding with such vital plans as Colonel Armstrong's design for an Aeromedical Center. They had to be deferred until the Air Force gained control of the human and material resources it needed to develop a specialized medical service.

On the day that the Air Force came into being, Doctor Strughold was aboard a troop ship, the S. S. *Alexander*, traveling from

Bremen to New York. (A fellow passenger was Dr. Walter Dornberger, who had been the major general in command of the German rocket facilities at Peenemünde.) Answering an urgent request from Harry Armstrong, the University of Heidelberg had granted Doctor Strughold a leave of absence. As it turned out, he was never to see Heidelberg again except as a visitor.

On August 2, Doctor Strughold landed in New York. The same evening, he was flown to Randolph in a B-25. Unlike the scientists who had preceded him, he was not assigned to a department. Instead, Colonel Armstrong kept him near at hand as an advisor and consultant. In effect, he was added to the small band of medical officers, headed by Grow, who were planning the future course of Air Force medicine.

By chance, Doctor Strughold had been at Randolph less than eleven weeks when an event occurred that was to reshape the whole character of aviation medicine, opening up illimitable vistas overhead for human exploration. That event was the flight of a little airplane that looked rather like a flying porpoise, at an obscure base half a continent away.

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Chapter 12

THE EXPANDING SKY

At Muroc, California, on the rim of Rogers Dry Lake, was the desert station later known as Edwards Air Force Base, where the Air Materiel Command tried out prototypes of new aircraft and safety equipment. There, on October 14, 1947, Captain Charles E. Yeager climbed into the crew compartment of a B-29 Superfort and composed himself for a long ride aloft.[1]

The 24-year-old test pilot was encased in a novel kind of costume. A skin-tight garment of nylon and cotton, with inflatable tubes fitted down the sides to draw it even tighter, it was the experimental T-1 partial pressure suit, designed to replace some of the atmospheric pressure removed from around the flyer's body at high altitudes.

But it was not to test the suit that Captain Yeager was making this particular flight. Suspended under the Superfort, in the open well of what had been the bomb bay, was an equally novel airplane. Smaller than most fighters, it was a bullet-shaped capsule, 31 feet long, carrying two and one-half tons of highly volatile combustibles, and crammed with complex instruments. Built by the Bell Aircraft Corporation under contract with the Air Force and the National Advisory Committee for Aeronautics, it was the first airplane powered solely by rockets, and it was called the X-1.

To Captain Yeager, who had been a fighter pilot, it was known more familiarly as Glamorous Glennis, after his wife.

The bomber trundled out onto the air strip, bearing its incendiary burden tenderly, turned into the wind, and took off. As it climbed over the flat bed of the vanished lake, Captain Yeager checked on last-minute data with the project engineer, Captain Jackie L. Ridley, and the flight surgeon, Major John Paul Stapp.

At 7,000 feet above the desert, he clambered onto a ladder in the bomb bay, and was lowered to a hatch on the side of the X-1. He opened the hatch and slid into the cramped cockpit, reclining among banks of dials and switches, under a skylight canopy. Now he conversed with the crew of the big plane overhead by radio, still exchanging data on the behavior of both aircraft.

At 21,000 feet, the X-1 was released from its mooring under the wings of the Superfort. As it fell free, the rocket engine came to life with a surge of enormous energy. Like a thoroughbred issuing from the starter's gate, the small craft leaped forward and streaked away, climbing into the cold, thin air on top of the world.

It took the four rocket exhausts in the tail exactly two and a half minutes to consume the liquid oxygen and alcohol in the tanks. They left the X-1 lighter by approximately half its takeoff weight, and accelerated it to a speed somewhere beyond 660 miles per hour.

After that, its power gone, the X-1 glided down to a dead-stick landing on the dry floor of the lake. The entire flight had taken fourteen minutes. When the recording instruments were checked and compared, they verified the fact that Captain Charles Yeager had become the first pilot to penetrate the so-called sonic barrier, flying an airplane faster than the speed of sound.

Breaking through the sound barrier was a feat of tremendous piloting skill and consequence. Quite properly, it captured the imagination of flying enthusiasts everywhere. But it was not the most important achievement of Captain Yeager's flight.

Essentially, the sound barrier was a range of speed—varying with the temperature of the air—in which aerodynamic forces tended to build up turbulence in front of the craft, producing shock waves that could conceivably destroy it. During the months before the flight, magazine and newspaper articles had toyed with the idea that the velocity of sound might define a natural limit for the speed of an object depending on wings for lift, much as the velocity of light defined the ultimate speed of objects in a vacuum.

Engineers saw little virtue in this notion. They were confident that an airplane could be designed to pass through the

barrier without harm, even though wind-tunnel tests had left them in doubt that the X-1 was that airplane. But Captain Yeager, on the strength of earlier trials in which he had cautiously approached the barrier in the X-1, had believed that it would fly beyond the critical point without trouble. He proved his point, thereby opening the realm of supersonic flight within the atmosphere to a new generation of jets as well as rocket craft.

To Harry Armstrong, pondering the implications of the flight in his office at Randolph Air Force Base, it appeared that the X-1 had passed through a much more significant barrier: the invisible line dividing atmospheric flight from space flight. For here at last was a vehicle providing wings for lift, so that it could fly like an airplane within the atmosphere, yet with the indispensable power plant of a space craft—a rocket engine, deriving thrust solely from the physical reaction to the expulsion of gases in its own exhaust.

Ever since 1935, when he had served as flight surgeon for the stratosphere ascent of the balloon *Explorer II*, Doctor Armstrong had been convinced that men were destined to travel routinely in the upper regions of the atmosphere, many miles beyond any altitude so far attained, and eventually even in the solitary fastnesses between the planets. The urge to explore the broad expanse of the sky was irresistible to the human mind. Where such an urge existed, the means to satisfy it surely would be found.

The jet airplane had done little more than whet this appetite. The jet offered a new dimension of speed, at levels a few miles above those where propeller-driven craft were seen. But jets were subject to the same limitation imposed on the slower planes which they had supplanted, and for the same reason. They depended on a certain amount of air to support their wings, and also to provide oxygen for combustion of the fuel that gave them their thrust. A jet exhaust was, so to speak, simply a blast of hot air. The practical ceiling for a jet aircraft was reached somewhere in the vicinity of fifteen miles up, where enough air remained (roughly 3.4 percent of the volume and pressure at sea level) to maintain these functions.

A rocket, on the contrary, needed no air at all. Its motion was a direct response to the energy of the gases leaving its ex-

haust. It carried its own oxidizer to support combustion in its fuel. Any air around it was a mere hindrance, impeding its progress. A rocket craft functioned more efficiently the higher it went. Its ideal medium was the near-vacuum of space. There it behaved like a celestial body, guided only by the acceleration forces which were fundamental to every particle in the universe—gravitation and the inertial velocity imparted to it by whatever had propelled it there in the first place.

The practical difficulty in flying a rocket craft was the enormous quantity of propellants which it consumed in attaining that velocity. The tiny X-1 burned a ton of liquid oxygen and alcohol each minute in its brief burst of powered flight. To reach the farthest ramparts of the upper atmosphere, and to remain there any length of time, would have taken a vehicle of fantastic size and weight, consisting almost entirely of the chemicals required to lift it.[2]

The classic solution to this dilemma was the technique known in rocketry as "staging." A very large rocket, carrying one or more progressively smaller rockets on top of it, was used to raise the whole structure off the ground and loft it to an altitude of a few miles. There the launch vehicle, its fuel exhausted, was detached and dropped away. Relieved of this burden, but with the initial speed derived from it, the second stage took off, accelerating rapidly as it soared into the thin air high above. At the effective border of the atmosphere, where scattered particles no longer impeded the progress of a fast-moving object, the intermediate stage in turn was discarded. The space craft remained, proceeding with the flight on its own.

Immediately after the War, in 1946, the Army Air Forces had adopted a program to develop an intercontinental ballistic missile.[3] It was the first design for the potent Atlas, which was to become in time the foundation of America's war-deterrent strength for the age of nuclear weaponry. A very large rocket indeed, it would have served admirably as a launching vehicle for a space craft—and was in fact to be used for just that purpose after a lapse of sixteen more years. But in 1947, shortly before Captain Yeager's record flight in the X-1, the program was canceled for reasons of economy, not to be revived until the nineteen-fifties.

The B-29 that lifted the X-1 above the denser layers of the atmosphere was a partial substitute for the rocket booster that

did not yet exist. But it lacked one vital characteristic of a rocket booster. No airplane could impart to the X-1 the high velocity at the start of its run that a rocket launching vehicle would have given it. For that reason, the X-1 never could attain either the astronomical speed or the prodigious altitude that would have enabled it to leave the restraint of the atmosphere and operate under the influence of cosmic forces alone.

For practical purposes, the upper limit of the Earth's air as a medium opposing the flight of a rocket was placed at a height of more than 100 miles. To pass beyond this boundary and soar—even for a short time—in the relative freedom of space, the rocket would have to be capable of speeds well above 10,000 miles per hour.

The top speed of the X-1, attained by Captain Yeager in another trial, some months after he had broken through the sound barrier, was 967 miles per hour.[4] Its peak altitude, reached in yet another test by Major Frank K. Everest Jr., was 13.8 miles. On that lofty pinnacle—remote indeed for an airplane—the X-1 still was a scant few hundred feet above the mark achieved by the balloonist in *Explorer II* a dozen years before.

Later rocket craft, larger and more powerful than the X-1, were to carry both of these records very much higher in the decades ahead. The X-15, built by North American Aviation, eventually would fly at speeds up to 4,500 miles per hour and would rise to a height of 67.09 miles. Yet, lacking a rocket booster to launch them, hybrid craft of this type could never hope to climb above the sensible atmosphere altogether.

Instead, their task was to explore the tenuous frontier between the habitable atmosphere and the void, from 10 to 100 miles overhead. Through this peculiar region of the sky—deficient in the useful properties either of the air or of a vacuum—every space craft would have to travel twice, on its way aloft and on its return. In both directions, the passage out of one medium and into the other brought stresses whose dimensions were not yet fully known, for the craft and for its occupants. Apart from the difficulty of controlling the vehicle, they included rapid acceleration or deceleration and extreme changes in temperature, especially during the descent, when the craft abruptly encountered the denser atmosphere below.

In spite of its limitations, then, the X-1 represented a practical approach to the technical and human problems of space flight. Also it was a direct approach, adopting as a foregone conclusion that men ultimately would travel far beyond the outermost fringes of the atmosphere.

From his experience at Wright Field, Harry Armstrong was aware that the normal lag between an experimental flight system like the X-1 and a craft which would actually deliver the required performance was ten to twenty years.[5] On that precedent, a vehicle which would carry men into space might be expected some time after the fall of 1957.

But the medical problems inherent in any such enterprise were so novel and complex that it would take at least ten or fifteen years to solve them. So, if his estimate should prove to be correct, the end of 1947 was none too soon to begin the search for medical techniques which would maintain the flyer's vital functions under the inhospitable conditions that were found in space.

Aviation medicine already had contributed to the success of the X-1. The Aero Medical Laboratory at Wright Field had worked with the Air Materiel Command on the design of all its equipment enabling the pilot to survive, to control its flight, and to record its performance at high speeds and high altitudes.

The T-1 partial pressure suit, in particular, was a product of the Laboratory that Doctor Armstrong had founded.[6] An outgrowth of earlier garments to support vulnerable areas of the body under the strong acceleration forces experienced during fast manoeuvres in jet aircraft, it had started in 1943 as a research contract with James P. Henry, M.D., a physiologist at the University of Southern California. At the end of the War, Doctor Henry had joined the staff of the Laboratory, completing the suit there.

Its purpose was to protect the pilot in an emergency at altitudes up to 20 miles, if the cockpit accidentally lost its built-in pressure. Inflating automatically, it would provide enough mechanical pressure on the body to sustain the pilot's respiration and his circulatory system for six minutes—long enough so that he could descend into the denser air below and land unharmed.

Later on, continuing development would produce a full pressure suit, which could be worn at higher altitudes for longer periods

of time. Eventually it would become a true space suit, surrounding the pilot with his private atmosphere for prolonged excursions outside the shelter of his craft.

The pressure suit, like the pressure cabin, filled an obvious need, if human beings were to venture into a medium where atmospheric pressure either was insufficient to support their physiological functions or was lacking altogether. Aviation medicine had been approaching this problem by degrees for more than a century and a half, since the first experimental balloon flights by the self-exiled physician from Boston, Dr. John Jeffries. Not all of the difficulties that men would have to overcome merely to survive in space were quite so evident. The physical phenomena that took place outside the atmosphere were not yet fully known. Their effects on living matter had scarcely been considered.

Before a systematic program of research on these problems could be laid out, an attempt must be made to define them. Accordingly, in the spring of 1948, Doctor Armstrong (newly promoted to brigadier general in May) appointed two of the scientists on his staff as a team to conduct this inquiry.[7] They were to survey the literature on physical conditions in the remote upper atmosphere and in space, singling out those which might be expected to cause medical difficulties if a flyer was exposed to them. From the nature of the difficulties, the search for preventive measures could proceed.

The two scientists were Dr. Hubertus Strughold, then serving as a personal advisor to General Armstrong on the medical effects of high-altitude flight, and Heinz Haber, Ph.D., the astrophysicist. It would be Doctor Haber's task to describe the physical environment in space, while Doctor Strughold would deduce their probable effects on the human organism.

Through the summer and fall, their collaboration went so well that General Armstrong decided to unveil some of the preliminary findings before a trial group of specialists on the medical problems encountered in flight. The occasion he selected was a panel discussion at the School of Aviation Medicine, jointly sponsored by the National Research Council, the Air Surgeon, the Laboratory at Wright Field, and the School itself.

Held on November 12, 1948, this meeting was the first professional gathering ever brought together to consider the biological

aspects of space flight. Besides Doctor Strughold and Doctor Haber, who presented formal papers, the panelists taking part in the discussion included Conrad Berens Jr., M.D., the New York ophthalmologist from the original staff of the Laboratory at Hazelhurst; D. Bruce Dill, M.D., of the Harvard University Medical School; John C. Flanagan, Ph.D., the psychologist, from the University of Pittsburgh; Andrew C. Ivy, M.D., University of Illinois; Lieutenant Colonel Adolph P. Gagge, from the Wright Field Laboratory; and a pair of Navy flight surgeons, Commander Charles F. Gell and Commander Merrill H. Goodwin.

In his opening remarks, Heinz Haber described the basic principles of rocket propulsion and celestial mechanics, by which travel outside the atmosphere had become possible. To many of the medical specialists in his audience, they were as exotic—and often baffling—as the principles of aerodynamics had appeared thirty years before.

As a practical procedure, the first step toward free flight in space was to attain sufficient speed so that the craft would enter a roughly circular orbit around the Earth. Orbital velocity varied according to the altitude, decreasing with the distance from the ground.[8] (The determining factor, of course, actually was the distance from the gravitational center of the Earth.) Just above the tangible atmosphere, the velocity was something over 17,425 miles per hour. At this speed, the momentum carrying the craft on a tangent away from the Earth exactly canceled the gravitational attraction drawing it back toward the ground. The result was that it continued to circle indefinitely at the same height, its rocket engine shut off, without applying any additional thrust.

To leave this orbit and travel toward another point in the Solar System, it was necessary to restart the engine and to build up a second increment of speed, approaching what was known as "escape velocity." Again the figure varied with the altitude of departure, with the distance to be covered, and with the attractions of celestial bodies such as the Sun and the planets. Escape velocity for a craft taking off directly from the ground ranged up to about 24,985 miles per hour. For one leaving a circular orbit, it would be somewhat less.

After that speed was reached, the engine could be shut off once more. From then on, the craft would coast toward its

destination, following a trajectory similar to the path of a comet or a meteor. In effect, it would have become a satellite of the Sun, subject only to the balance of the gravitational forces in the universe around it.

The rate of acceleration required to achieve escape velocity was large, ranging as high as ten times the ordinary pull of gravity at the Earth's surface.[9] But tests on centrifuges—by General Armstrong at Wright Field, among others—had shown that accelerations of this order were within the limits of human tolerance, if the flyer's body was properly positioned and supported.

A much more perplexing situation arose when the rocket thrust of the engine was suspended, either in orbit or on a parabolic trajectory in space, and the craft coasted in a state of balance with the gravitational forces acting upon it. For then it was responding to these attractions without resistance, like a body falling toward the Earth in a vacuum. The result was that the craft and its contents were weightless, relieved of the impediment to gravitation normally provided by the atmosphere, by the deck of the vehicle, or by the solid surface of the ground itself, preventing a free fall toward the source of the attraction.

This was a condition that men had never experienced except briefly, in a rocket craft such as the X-1 at the top of its climb, for a few seconds before it began its descent through the atmosphere again. Prolonged weightlessness, over a period of hours or days or weeks, was a state which could not be induced experimentally in a laboratory on the Earth. What its effects might be on the human mind or body could only be a subject for theoretical analysis until the first manned vehicle actually orbited in space.

Other problems touched on in the meeting were more susceptible to study on the ground. Among them were the effects of solar and cosmic radiations, the orientation of the flyer in the novel surroundings of space, temperature variations, the hazard of colliding with a meteorite, the pressure and composition of the atmospheric gases in the cabin, isolation and confinement, and the environments on other celestial bodies in the region of the Earth.

Considering the novelty of these problems, the discussion gave a remarkably accurate survey of the major difficulties facing men in space, as they were known or postulated in the closing

months of 1948. To General Armstrong, it furnished reassurance that a firm foundation did indeed exist for an experimental program which would develop adequate medical safeguards for the future astronaut.

Early in January, he called upon the staff to submit detailed proposals for research projects to be carried out in their specialized areas.[10] The most comprehensive plan came from Doctor Strughold. After consulting with Doctor Haber, he recommended that a separate department should be created to explore the human responses to flight beyond the atmosphere. As the name of the department, he suggested "space medicine," a term which he had introduced for the first time in the panel meeting.

The Department of Space Medicine was officially organized at the School on February 9, 1949. Its founding members were Doctor Strughold and Doctor Haber. Until May, General Armstrong acted as the administrative head of the Department. After that, he left its direction to Doctor Strughold.

In the next months, its membership would be increased to four, with the arrival of Konrad Buettner as a bioclimatologist and Fritz Haber as an authority on aerodynamics and structural design. Together, this quartet of transplanted German scientists would become the architects of a new discipline in medicine—the art of enabling men to live in the desolate reaches which comprised all but a single known body in the natural universe.

The Department had scarcely started on its inquiry when Harry Armstrong was called to Washington once more.[11] On July 1, 1949, the Air Force finally took possession of its medical service. Major General Malcolm Grow, after two and a half years as the Army Air Surgeon, became the Surgeon General of the Air Force. Harry Armstrong—now a major general too—was to be his deputy.

Grow's appointment, on the eve of his retirement, was intended to recognize the fact that the Air Force Medical Service was largely his creation. In November, he was to end his career as an active medical officer, and retire to a home on the outskirts of Annapolis, Maryland, where he would be accessible if his counsel was needed. Armstrong then would be the Surgeon General.

The successor to Armstrong at the School of Aviation Medicine was the same flight surgeon who had followed him as commander of the Laboratory at Wright Field nine years before: Otis O.

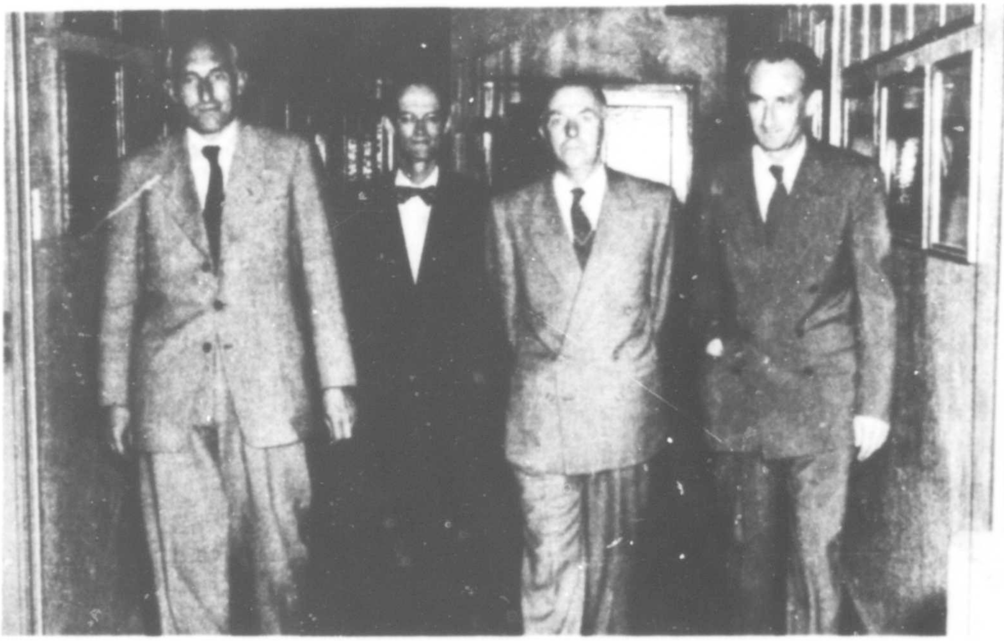

FIGURE 18 —

The first Department of Space Medicine was organized at the School in February 1949. It was headed by Dr. Hubertus Strughold and included (left to right) Dr. Fritz Haber, Dr. Konrad Buettner, Dr. Strughold and Dr. Heinz Haber.

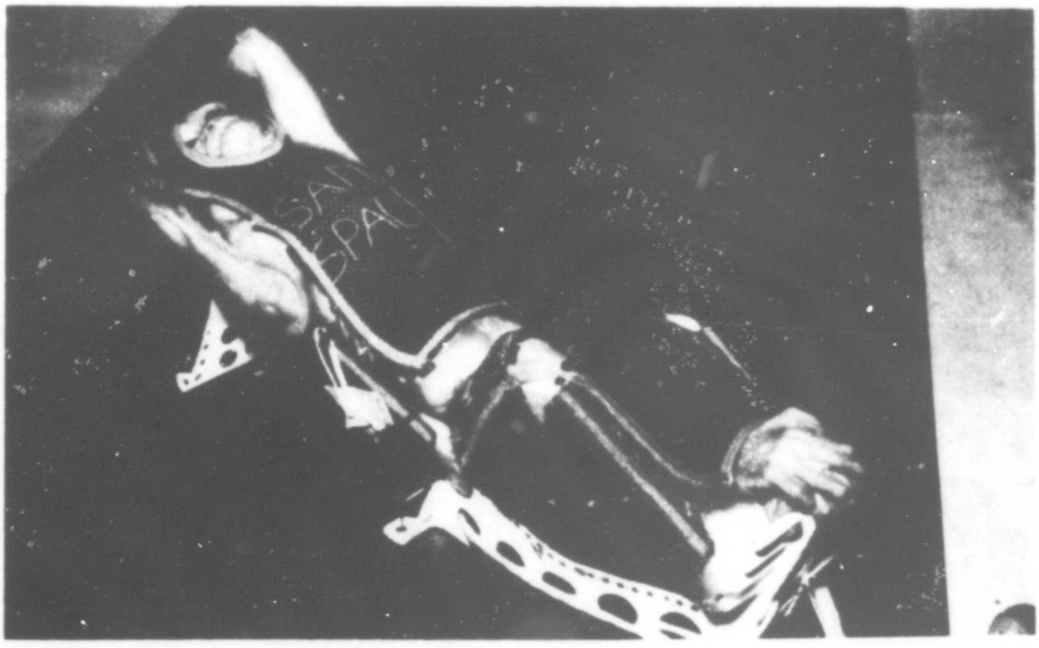

FIGURE 19 —

This primate was lifted 55 mies into space from Wallops Island in December 1959. His capsule was designed at the School where he was trained for his historic flight.

FIGURE 20 —

President Lyndon B. Johnson, then U.S. Senate Majority Leader, greeted Airman Donald G. Farrel as he emerged from a space chamber after a 7-day simulated space voyage at the School, Feb. 16, 1958.

Benson Jr. From there, in 1943, Doctor Benson had gone overseas to become the wartime Surgeon of the Fifteenth Air Force in North Africa and Italy, and later Surgeon of the Air Forces in the Mediterranean.

At the end of the War in Europe, he had been called back to Washington like General Armstrong, to become Director of Medical Research in the office of the Air Surgeon. Colonel Benson had just completed a year of study at the National War College when he arrived at Randolph on July 6, 1949, to command the School of Aviation Medicine. Two months later, in September, he was advanced to brigadier general.

The professional background, interests, and objectives of General Armstrong and General Benson were closely parallel. But in temperament and style they were quite different. General Armstrong was calm and attentive almost to the point of seeming diffident. The impression he gave was the reflective one of a scholar, with a certain quiet humor that showed itself more in his attitude than in his speech. He exerted his influence largely by virtue of the respect accorded to his knowledge and achievements.

General Benson was of Scandinavian and French ancestry. In appearance he was Nordic, but his personal charm and wit were rather more Gallic. Versatile, quick, and expressive both in words and in action, he made his presence felt mainly by the force of his animation and intelligence, often arriving at the point of a discussion with such rapidity that his associates were baffled by the reasoning which had led them to it. Under his direction, every detail of an organization was known to him and subject to his immediate guidance.

The School that General Armstrong handed on to General Benson already had regained much of its wartime strength and enthusiasm for research. Although the infusion of German scientists had contributed greatly to this resurgence, it was not solely responsible. Doctor Armstrong had exercised his recruiting skill to draw fresh talent from a variety of other sources.[12]

Several officers on active duty at the School during the War, and demobilized afterwards, had returned to the staff a year or two later as civilian specialists. Among these were two department heads conducting research of more than casual interest to the Air Force. They were Herman I. Chinn, Ph.D., in Pharmacology and Biochemistry, and Roland B. Mitchell, Ph.D., in

Aerobiology. During their absence, both had been with the Florida State Board of Health.

A number of talented civilians had been attracted to the School since the War. They also included two department heads. Physiology and Biophysics, with the largest staff and the greatest diversity of projects, now was under Harry F. Adler, M.D. (Doctor Adler later would leave the School to enter private practice in San Antonio.) Saul B. Sells, Ph.D., was in charge of the new Department of Clinical Psychology, studying the basic personality traits of flyers.

Almost without exception, the senior medical officers were outstanding flight surgeons with wartime experience overseas. The Deputy Commander and Director of Education, Colonel Frederick J. Frese Jr., had served with General Douglas MacArthur's Thirteenth Air Force in the campaigns from Guadalcanal to New Guinea.

Colonel Victor A. Byrnes had returned from the Pacific after the War for his second tour as head of the Department of Ophthalmology. Doctor Byrnes also was Director of Clinical Medicine, one of the two divisions under which the departments now were grouped.

The Director of Medical Sciences was Colonel Don Flickinger, who also headed the Department of Internal Medicine. Doctor Flickinger had been Flight Surgeon of the air transport wing flying "The Hump" over the Himalayas in the lonely China-Burma-India Theatre.

Lieutenant Colonel Robert B. Lewis had been captured on Bataan in 1942 and had spent the balance of the War in a Japanese prison camp. As the head of Pathology, he specialized in research on the treatment of cold injuries ("frostbite").

Lieutenant Colonel John M. Talbot had been a flight surgeon with the Eighth Air Force in England, and later medical officer for Operation Crossroads, the nuclear test drop off Bikini Atoll in the Pacific. As head of Radiobiology, he was concerned with measures for medical defense against nuclear weapons.

One of the younger men on the staff, incidentally, was noteworthy for the breadth of his qualifications. Lieutenant Colonel

Charles H. Roadman, 35, had come to the Randolph Hospital at the start of the War as a medical officer, had taken the flight surgeon course at the School, had then entered pilot training, and had become a flight instructor.

After the War, Doctor Roadman had returned to the School as head of Preventive Medicine, later as director of flight operations, and finally as Executive Officer under General Armstrong. Within the next year, after attending the Air Command and Staff School, Colonel Roadman would be appointed Command Surgeon at Air University Headquarters.

Even though a noticeable fraction of the School's energy now was absorbed in exploratory studies of the upper atmosphere and space, it had by no means diverted attention from the more familiar areas of medical science. On the contrary, the School had enlarged both its interest and its competence to cover the entire range of biological problems associated with flight. Under Armstrong's leadership, the School had again become the prime source of therapeutic knowledge and procedures in aviation medicine.

No sooner had the Air Force been assured of a separate medical service than the project to develop the School into an Aeromedical Center was revived.[13] In the spring of 1949, General Hoyt S. Vandenberg, the Chief of Staff, had approved it. In May, it had been endorsed by Secretary of Defense James Forrestal. The Air Force had been directed to "plan, administer, operate, and exercise policy control of . . . research and development in aviation medicine and the aeromedical program, including an aeromedical center."

One of General Armstrong's first acts, on his arrival in the Surgeon General's office, was to appoint an Aeromedical Center Planning Board for the purpose of making specific recommendations on the facilities that would be needed. The Chairman of the Board was General Benson. The other members were Colonel Frese, Colonel Byrnes, Doctor Adler, Colonel Benjamin A. Strickland Jr., and Lieutenant Colonel Jack Buel, from the staff of the School; Major William A. Hill, Major Kenneth B. Johnson, and Major William F. Sheeley in the office of the Surgeon General; and Colonel George F. Baier III at Air University Headquarters.

Before the plans formulated by the Board were transformed into fact, they would be modified several times in various respects and ten years would elapse. Nevertheless, the project had been launched with the official blessing of the Defense Department.

Eventually an Aeromedical Center was to arise on a tract of real estate all its own, and General Benson, after watching over its progress through the years, would become its first commander.

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Chapter 13

WHERE SPACE BEGINS

The decade that opened with the founding of the Department of Space Medicine at Randolph was a period of enormous energy and ingenuity in the search for knowledge of the flight environment beyond the useful atmosphere, and of its effects on living organisms. Too, it was a period when other institutions besides the School of Aviation Medicine began to study these effects, and was marked by the widespread growth of public interest in them.

Perhaps the first agency outside the Air Force to embark on studies of this kind was the National Institutes of Health at Bethesda, Maryland.[1] At about the time that General Armstrong had been fortifying the staff of the School with German scientists, the Institutes had arranged with Army Ordnance to incorporate some biological experiments in the V-2 rockets which were test-fired at the White Sands Proving Ground, west of Alamogordo, New Mexico.

Cylinders containing fruit flies were packed into the nose compartments of the missiles, replacing the armed warheads which they had once carried, and were lofted into the upper air to determine the effects of exposure to cosmic radiation. One such cargo was returned to the ground by parachute and recovered intact, after soaring to a height of 106 miles. The fruit flies apparently were in good health.

Other Government research organizations were allotted space in the rockets for similar experiments. Among them was the Aero Medical Laboratory that General Armstrong had founded at what was now Wright-Patterson Air Force Base, Ohio. There Dr. James P. Henry—who had developed the partial pressure suit—devised a more ambitious program. He designed a capsule roomy enough

to carry small animals, such as Rhesus monkeys and mice, and to support their respiratory functions while they were aloft. Essentially, it was a miniature of the air-tight gondola that had maintained the stratosphere balloonists in the ascent of *Explorer II*.

In this capsule, during 1949 and 1950, Doctor Henry sent up a series of animal subjects at White Sands, with equipment to record their responses to a variety of dynamic and environmental conditions, including rapid acceleration and weightlessness. To prepare the experiments and compile the results, the Laboratory established a field station at Holloman Air Force Base, on the edge of Alamogordo, where the rocket development facilities of the Air Force were concentrated. The project engineer on the spot was a young medical officer, then in his late twenties, Captain David G. Simons. More would be heard of Doctor Simons as the decade progressed.

From the V-2 shots, Doctor Henry acquired a good deal of recorded data on the reactions of his subjects. But the automatic system to release the capsule and lower it gently to the ground by parachute invariably failed. The animals could not be recovered alive for post-flight examinations.

Then the Air Force put a new research rocket of its own, the Aerobee, in service. More room was provided in the Aerobee for Doctor Henry's experiments, and the launch site was shifted to Holloman, where better tracking and control facilities were available.

On September 20, 1951, Doctor Simons sent aloft a capsule carrying a Rhesus monkey and eleven mice, two of them enclosed in a revolving drum fitted with a camera to film their behavior during acceleration and weightlessness. The Aerobee took them to a height of 44.7 miles—nearly three times the record altitude attained a few weeks earlier at Edwards Air Force Base by Test Pilot William B. Bridgeman in the Douglas D-558-II rocket aircraft.

This time the parachute recovery system worked as it was meant to, and the animals landed in the capsule unharmed. The monkey died two hours after impact, evidently of heat prostration while it waited for a search party to find and open the capsule. Two mice also died later, presumably from the same cause. The other nine survived without any permanent ill effects from the hazards they had experienced.

They were the first animals known to have been recovered in good condition after a rocket flight through the lower depths of space. Doctor Henry's film sequence of the mice clinging to their drum for support, while the vehicle coasted at the top of its trajectory, was particularly impressive. It conveyed a vivid suggestion—if a less than conclusive one—of the confusion that might overtake a flyer during weightlessness. For this experiment, among others, Doctor Henry was to be honored with awards from both the Aero Medical Association and the Institute of the Aeronautical Sciences.

Two months after the successful Aerobee shot, the biological test station at Holloman was inaugurated as a full-fledged research facility in its own right: the Aeromedical Field Laboratory, specializing in studies of high-altitude environmental conditions and flight equipment. Through the nineteen-fifties, it was to acquire considerable renown for some of its more spectacular programs, as well as for the light which they would shed on the practical difficulties confronting the flyer as he left the shelter of the Earth's atmosphere.

In spite of the growing interest in the biological effects of space flight at Holloman and elsewhere, the School of Aviation Medicine still was the most active center for research in the new discipline which it had conceived. Also it was the one which attracted the most attention. Both its activity and the dispersion of its influence might be said to have started with a relatively modest yet provocative paper, produced in 1950 by Doctor Strughold and his colleagues.[2] Later published in *The Journal of Aviation Medicine*, it was called "Where Does Space Begin?"

From the outset of his inquiry into the problems of space medicine, Doctor Strughold had been bothered by the fact that no orderly system yet existed to classify the problems in physiological terms. The method followed so far had been to examine the physical conditions encountered in space flight, and from these to deduce the physiological effects as they appeared. But Doctor Strughold's scientific training told him that the study of space as a living environment should be founded on the responses of the human organism directly exposed to it.

With that criterion in mind, he asked himself: At what point in the ascent of a flyer does the atmospheric environment end

and the environment of space begin? The more he considered this question, the more evident it became that there was no well-defined boundary between the functional properties of the atmosphere in human physiology and the lack of them in space. Instead, there was found a succession of boundaries at progressive altitudes. where specific functions of the atmosphere terminated.

The first of these boundaries was met at a height of only 10 miles. There the pressure of the atmosphere was reduced to about 87 millimeters of mercury. But the flyers's lungs were filled with water vapor and carbon dioxide—both produced within the body—to a constant level of 87 mm Hg. Hence, if he should be exposed to the atmosphere by a sudden failure of his pressurized cabin or suit, he could draw no more oxygen into his lungs, even though oxygen still was present in the ambient air.

The flyer then would have as much as 15 seconds in which to take some remedial action, before he lost consciousness from lack of that life-supporting gas. This period of grace (extended somewhat in later research) was provided by the time it took to consume the oxygen already absorbed into his blood stream and tissues. No matter how far he might travel into space, the time allotted him by his own circulatory system would be the same. With regard to this physiological function, he was already in space.

At an altitude of 12 miles, under similar circumstances, a more drastic situation occurred. Here the pressure of the atmosphere dropped to about 47 mm Hg. General Armstrong had shown that, when this pressure was reached, water and other fluids in the body—including the blood—would begin to vaporize at the normal temperature of the body itself, 98.6° Fahrenheit. From this point on, a flyer exposed to the atmosphere would be subject to the same desiccating process that attacked his tissues in the farthest reaches of space.

Above this altitude, also, other difficulties set in. For technical reasons of weight and bulk, it became impractical to pressurize the cabin by compressing the rarefied air outside. Moreover, in the region from 12 to 18 miles up, ultraviolet light radiation from the Sun dissociated the oxygen molecule (O_2) into its component atoms, which then combined to form molecules of ozone (O_3) in concentrations that were toxic to the human body. Therefore,

beyond 12 miles, the flyer had to be isolated from the atmosphere altogether, in a sealed cabin providing its own air under pressure. Just such a cabin was required anywhere in space.

Above 18 miles, the unshielded body was exposed to the blistering action of ultraviolet light itself. At the same height, it was no longer protected from heavy primaries of cosmic radiation. Above 70 miles, the craft was subject to the full impact force of meteorites. At 95 miles, the density of the atmosphere was insufficient to scatter visible light, and the darkness was absolute except in the direct rays of luminous objects. Somewhere beyond 100 miles, the atmosphere provided neither mechanical support nor restraint to the body in an orbiting vehicle, and the flyer was weightless for an indefinite length of time.

The import of this paper to the physiologist was twofold. First, it set forth a clear and comprehensive sequence of human problems in space flight to be resolved by medical science. Secondly, it demonstrated that space—from the physiological point of view, at least—was not situated somewhere in the remote yonder, far overhead, waiting to be explored by a future generation of flyers. On the contrary, space-equivalent conditions were found to begin only a few miles above the ground, where experimental aircraft such as the X-1 and the D-558-II already were operating.

But a physical implication also could be drawn from this deduction. If space equivalence—both for the pilot and for the airplane—was encountered first a mere 10 to 12 miles up, in the lower level of the stratosphere, and was virtually complete at a height of about 100 miles, still well within the ionosphere, what became of the traditional distinction between the physical properties of the atmosphere and of space?

It was now generally considered that the Earth's atmosphere extended to a distance of approximately 400 miles, where it ceased to behave as a gas in even the most attenuated state.[3] But the boundary was by no means a precise one. Instead, no matter how far the flyer might travel beyond the Earth, atmospheric and other particles would be found, although the separations between them were so great that they rarely met. In fact, the stars and planets, with their atmospheres, could be thought of simply as local concentrations of the same matter that existed—in a diffuse state—everywhere in space.

If that idea was valid, then there was no essential difference between the atmosphere and space, except in the density of their particles and the consequent frequency of interactions between them. The "normal" flight medium then was space, while the atmosphere—vital though it was to the human organism—might be viewed as little more than an impediment to travel through the cosmos.

This concept, arising out of the classic paper by Doctor Strughold and his associates, was to intrigue the Air Force more and more as the decade progressed, because it embraced the entire field of action in which flight could occur. Eventually it would lead to the adoption of the term "aerospace" to designate the flight medium as a whole, from the ground to infinity, replacing such words of limited application as "aeronautics" or "aviation." The change of nomenclature was to be most marked in Air Force agencies participating in advanced research.

Thus, by the end of the decade, or soon thereafter, the Air Force Office of Scientific Research would have evolved into the Air Force Office of Aerospace Research; the Experimental Test Pilot School at Edwards Air Force Base would become the Aerospace Research Pilot School; the Research Studies Institute at Air University would be called the Aerospace Studies Institute. Similarly, the Aeromedical Center was in time to be established as the Aerospace Medical Center; the Aero Medical Laboratory in Dayton would be transformed into the Aerospace Medical Research Laboratories; and finally the School of Aviation Medicine, where this movement had begun, would abandon its traditional title, to be renamed the School of Aerospace Medicine.

The same trend was to be followed by industrial organizations and professional societies. The aircraft industry, along with many of its individual companies and trade associations, would come to be known as the aerospace industry. The Aero Medical Association was to be converted into the Aerospace Medical Association. *The Journal of Aviation Medicine* then would be called simply *Aerospace Medicine.*

Indeed, no other occasion comes readily to mind when a new physical concept, growing out of an innovation in medical thought, has been so widely accepted. It would be reasonable to say that

the basic idea expressed in "Where Does Space Begin?" was ultimately to ease and quicken the transition from atmospheric flight to space flight in America, offsetting somewhat the delay in development of true orbital vehicles by the United States.

None of this long-term effect, of course, could be foreseen in 1951, when the paper first appeared. The most that General Benson had expected was that this original view of the border zone between the lower atmosphere and space might be received with interest in professional circles. The means that he had chosen to disseminate it was the same procedure that General Armstrong had used effectively two years earlier, to introduce the subject of space medicine. He was planning to advance it at a scientific meeting.

But this was to be a much broader and more impressive meeting than the panel discussion which the School had presented in 1948. It would be a public symposium, open to the press, offering papers by authorities of international repute in both the physical and the biological sciences concerned with the atmosphere and space. The program would run for four days at the Plaza Hotel, in downtown San Antonio, and would be climaxed by a banquet for the participants.

A modest preview of this assemblage had been offered in the spring of 1950. Sponsored by the University of Illinois, it had been held in Chicago, with Andrew C. Ivy, M.D., Vice President and Professor of Physiology, as chairman.[4] That meeting had been notable because Dr. Wernher von Braun had appeared as one of the speakers, on multi-stage rockets and artificial satellites. Another speaker (on orientation in space) had been Paul A. Campbell, M.D., wartime Director of Research at the School, and then in private practice once more as an otolaryngologist in Chicago.

Bringing their contributions together with papers by General Armstrong, Doctor Strughold, Dr. Heinz Haber, and Dr. Konrad Buettner, the proceedings of the Chicago meeting were published in 1951 by the University of Illinois Press under the title, *Space Medicine: The Human Factor in Flight Beyond the Earth.* A slim volume of 83 pages, edited by John P. Marbarger, Ph.D., Associate Professor of Physiology at the University, it had the distinction of being the first book on space medicine.

Yet the scope of that meeting had been too small and intimate to attract much more than local attention, except among specialists on flight physiology. Its prime achievement had been to endow space research with an aura of academic propriety, removing it from the exclusive province of science fiction.

Wernher von Braun was to be a contributor also to the 1951 Symposium on the Physics and Medicine of the Upper Atmosphere.[5] So was Paul Campbell, who had been persuaded to give up his practice for the second time in the fall of 1950, had accepted a commission as a colonel in the Regular Air Force, and had returned to the School of Aviation Medicine as General Benson's Director of Research.

This time, however, they were only two among thirty-eight invited speakers on the program, including some of the most noteworthy names in the physical and biological sciences. There was, for example, a Nobel laureate in physiology and medicine, Herman J. Muller, Professor of Zoology at Indiana University in Bloomington. Dr. Marcel Nicolet, from the Meteorological Institute of Belgium in Brussels, was the authority on solar physics and its effects within the Earth's atmosphere.

Some other figures of high distinction in the academic sphere were Titus Carr Evans, Ph.D., head of the Radiation Research Laboratory at the State University of Iowa; Joseph Kaplan, Ph.D., Professor of Physics, University of California at Los Angeles; James A. Van Allen, Ph.D., Professor of Physics at the State University of Iowa, who would discover the twin radiation belts trapped high in the Earth's magnetic field seven years later; and Fred L. Whipple, Ph.D., chairman of the Department of Astronomy at Harvard University.

Civilian scientists associated with the Government on the program included James P. Henry, M.D., from the Aero Medical Laboratory, then in the first flush of his recent triumph with the recovery of live animals from a rocket flight at Holloman Air Force Base; Edward O. Hulburt, Ph.D., Director of Research for the Naval Research Laboratory in Washington, D.C.; Homer E. Newell Jr., Ph.D., head of the Rocket-Sonde Research Branch of the same Laboratory; and Heinz Specht, Ph.D., from the National Institutes of Health in Bethesda, Maryland. All were to become eminent figures in space research during the decade ahead.

The School's representation also was largely civilian, consisting of the four members of the Department of Space Medicine, together with Paul A. Cibis, M.D., discussing visual problems, and Ulrich C. Luft, M.D., on physiological limitations in the space-cabin environment.

Only six medical officers were on the program. Besides General Armstrong, General Benson, and Colonel Campbell, they were Colonel John M. Talbot, the radiobiologist, who had just left the School for the newly organized Air Research and Development Command of the Air Force in Baltimore, Maryland, and a pair of Navy flight surgeons: Captain Ashton Graybiel, Director of Research at the Naval School of Aviation Medicine in Pensacola, and Commander Ralph L. Christy Jr., from the Navy Department in Washington.

Joining in the discussions, though not presenting formal papers, were the test pilots of the X-1 and the D-558-II, Major Charles E. Yeager and William B. Bridgeman, a former Navy flyer. The speakers at the banquet were retired Lieutenant General Ira C. Eaker, chief of the Air Staff in World War II and now a vice president of the Hughes Tool Company, and retired General Carl Spaatz, the first Chief of Staff of the Air Force, who had since been writing and speaking on public affairs.

Although the School at Randolph was the sponsor of the Symposium, General Benson had contracted with a civilian medical institution to handle the arrangements. That institution was the Lovelace Foundation for Medical Education and Research in Albuquerque, New Mexico.

The connection between the School and the Foundation could be traced back to the nineteen-thirties, when General Armstrong and General Benson both had been associated with a group of young research physicians at the Mayo Clinic.[6] One of that group had been Dr. W. Randolph Lovelace II, an officer in the Medical Reserve of the Air Corps, a graduate of the School at Randolph, a flight surgeon, and a pilot. Already, at 32, the chief surgical assistant to Dr. Charles W. Mayo, in 1940 he had shared the Collier Trophy with Harry Armstrong and Dr. Walter M. Boothby for the development of the high-altitude oxygen mask. (Doctor Boothby, nearing the close of his life, now was General Benson's Advisor for Research.)

Called to active duty in the spring of 1942, Doctor Lovelace had been assigned to the Aero Medical Laboratory under Otis Benson's command. After Benson's departure for North Africa the next year, Colonel Lovelace had succeeded him as commander. Among his other achievements in that position, he had won the Distinguished Flying Cross for a delayed-opening parachute jump from a height of 7.6 miles, injuring one of his hands by accidental exposure to sub-zero cold during the descent.

After the War, Doctor Lovelace had decided not to resume his career at the Mayo Clinic. Instead, he had returned to Albuquerque, his boyhood home, where he had opened a clinic and research laboratory of his own, modeled on the world-famous one in Minnesota, but specializing in the medical problems of flight. Appointed the Medical Director of Trans-World Airlines in the spring of 1947, Doctor Lovelace had in just four years built the Lovelace Foundation into a private center of considerable prestige for the study and practice of aviation medicine.

In charge of the arrangements for the Symposium was Clayton S. White, M.D., Director of Research for the Foundation and head of its clinical section on aviation medicine.[7] Doctor White and General Benson together were to edit the proceedings for publication by the University of New Mexico Press. A massive book of more than 600 pages, *Physics and Medicine of the Upper Atmosphere* would become the basic reference for investigations of the aerospace environment in the early nineteen-fifties.

Opening at the Plaza on November 6, 1951, the Symposium turned out to be an unprecedented success. Although invitations had gone only to persons and agencies with a known interest in the subject, at a time when there was as yet no formal program of space exploration in the United States or abroad, some four hundred physical and biological scientists and engineers attended the meeting. Drawn for the most part from aeronautical laboratories of industry or the Government, they also represented universities and other institutions conducting independent research on atmospheric or cosmic phenomena.

More than that, the Symposium was a surprising popular success. It was treated with a mixture of deference and enthusiasm, not only by batteries of reporters and photographers for the local newspapers, radio, and television, but by the science editors of the

Associated Press and a number of large metropolitan dailies as well. Together, they saw to it that news of the meeting in San Antonio was widely disseminated in lay circles.

The visiting press included writers for four national magazines: *Aviation Age*, *Collier's*, *Reader's Digest*, and *The Saturday Evening Post*. Cornelius Ryan, from the staff of *Collier's*, was accompanied by a noted illustrator of scientific subjects, Chesley Bonestell. From their collaboration, a few months later, came a series of articles signed by participants in the Symposium—among them Doctor Heinz Haber, Doctor Kaplan, Doctor Von Braun, and Doctor Whipple. The series afterwards was expanded into a book, *Across the Space Frontier*, distilling much of the technical material presented at the Plaza into terms readily understood by the general reader.[8]

One result of the press coverage lavished on the Symposium was to bring the School of Aviation Medicine a kind of celebrity which had overlooked it in the past. Hitherto, the School had enjoyed a worldwide reputation, but one limited almost entirely to the fields of interest embraced by its peculiar specialty—to the flying fraternity, to the areas of science and technology concerned with the flight environment, and to those elements in the medical profession with which it was most intimately associated. Now, besides, it was an object of curiosity to the public at large.

The basic reason for its unforeseen exposure to popular scrutiny was that the School, at this early date, was the only well-established institution of any size and consequence conducting a serious and systematic inquiry into the feasibility of space flight. The upper levels of the Government just then were deeply absorbed in developing a firm defense against the awesome hazards arising from the growth of nuclear weapons and of automatic missile systems to deliver them. Most of the formal programs touching on the use of space as a potential scene of human action were strictly guarded, in the interest of national security.

But the studies of space carried on by the School at Randolph still were largely theoretical, without any direct relationship to defense measures or systems. In common with nearly all the other products of medical research, they were wholly humanitarian in their ultimate purpose, which was to protect the life and health

of the flyer. In accordance with the hallowed tradition of scientific discovery, the findings were reported at open meetings like the Symposium and then were published in professional journals, where any interested reader in any country could ponder their significance. There would have been no point in denying the press access to them.

So the School came to be regarded as a prime authority on the exploration of the cosmos. From this time on, until the creation of a national space agency toward the close of the decade, the laboratories at Randolph entertained a constant stream of visiting newsmen, feature writers, film and television producers, and authors of books and magazine articles, often from abroad, in search of material on the technical and human aspects of flight beyond the atmosphere. Some of the more illustrious medical officers and scientists were invited to describe their work before august assemblies with only a tenuous interest—if any—in space activities or public health. They were called upon for advice by Congressional committees.

This kind of notoriety was less than gratifying to the staff as a whole. To many physicians, on the contrary, it was a source of embarrassment. They had been imbued with the ideal of reticence which was cultivated in the healing profession. To be quoted by name in a newspaper struck them as bordering on self-advertisement, a breach of medical ethics. Worse than that, it suggested that they might be accused somehow of having violated the sanctity of the confidential relationship between a patient and his doctor. They would have been happier if they could have pursued their studies in the twilight of personal anonymity, except when they announced the results in the abstruse idiom of scientific journals.

Nevertheless, their newfound eminence was an advantage to the School in forwarding such projects as the Aeromedical Center. Formerly, as a specialized medical activity within the Defense Department, they had relied solely on its prestige among the military and professional groups with which the School was affiliated to advance its fortunes. When requests for money to support it had gone to the Congress, the member on whose protection they had mainly counted had been the Representative for its own district in Texas, Paul J. Kilday, who also was a ranking member of the House Armed Services Committee.

Now, as a consequence of the notice which it had received, the School had been elevated to the status of a national institution. It was identified—uniquely so far—as the symbol of American leadership in the new and dazzling field of space exploration. Without compromising its professional principles, it could expect the favor of Congressional champions whose outlook ranged beyond the immediate interests of their constituents. Not the least of these allies was the junior Senator from Texas, Lyndon B. Johnson, who was to be chosen by the Senate as Majority Leader two years later.

The most awkward barrier to the progress of the Aeromedical Center, though, had never been Congressional indifference. Rather, it was the reluctance of budget watchers within the executive branch of the Government to ask Congress for the money to build it.[9] Since 1949, when the program had been approved by Defense officials, construction costs had risen sharply. At the same time, Air Force commitments for operational facilities and equipment had been growing. The Center project went ahead, but in an atmosphere of increasing fiscal uncertainty.

While these factors were being weighed within the Air Force, the need for the Center had become even more acute. In the fall of 1950, after the outbreak of war in Korea, the renewed expansion of research and medical instruction had impelled the School to remove some of its activities from Randolph. All the teaching courses except those for medical officers had been transferred to a branch at Gunter Air Force Base, outside Montgomery, Alabama. They were to be reunited with the main body of the School when the Aeromedical Center was established.

By November 1951, when the Symposium was held, a site had been decided on for the Center, and definitive plans for the buildings were being drawn by a team at the School under the direction of Colonel Frederick J. Frese Jr., the Deputy Commander. After viewing possible locations in Miami, Florida, in Pasadena, California, and in Denver, Colorado, the Site Selection Board at Headquarters had recommended a spot only sixteen miles or so by air from Randolph. It was at Brooks Air Force Base, where the School had spent its first five years in Texas.

Brooks had been chosen principally for three reasons. It was Air Force property already; it was now inactive, except for weekend flying by Reserve units; and it enclosed a substantial amount

of empty land on which the Center could be situated. The original base had grown up around an arc facing the southeast corner of the reservation, where the runways were. There still remained some 375 or more brush-covered acres, mostly on high ground in the northwest corner and along the highway beside the northern boundary of the base.

Other considerations had entered into the decision. One was that the proximity of Brooks to Randolph would make the transfer easier and less expensive. Another was that the existing structures at Brooks—antiquated though the great majority of them were—would shelter some of the Center's operations until all of its new buildings were completed. The construction program had been divided into three stages, to be funded separately over a period of several fiscal years. The first group of buildings would house the research laboratories and teaching functions. The second would contain the clinical elements (including a 350-bed research hospital), the Library, and the Center Headquarters. Last would come the living quarters and support activities.

A request for $10,000,000 to build the first group, with an authorization to build the second group afterwards, was forwarded to the Bureau of the Budget for review and approval in February 1952. The Bureau marked down the cost of the first group to $8,000,000, postponed the authorization for the second until a later budget, and sent the request on to the Capitol. The funds were included without any protest in an appropriation bill passed by the Congress in July 1952.

But that was not the last of the obstacles standing in the way of the Center. Although the Air Force had been granted the means to make a start on the project, they were not to be released by the Budget Bureau for several more years, after further reductions in the scope of the services to be provided.

In fact, when ground was finally broken for the new installation at Brooks in May 1957, it would have been shorn of the hospital, the Center Headquarters, the Library, some of its specialized laboratories, and all of its living quarters and support facilities. Most of them would be restored later. But, in the mean time, the original plan would have shrunk so drastically that the Air Force no longer would refer to it as the Aeromedical Center. Instead, it would be called simply a new home for the School of Aviation Medicine.

That it survived at all could perhaps be attributed to the public interest generated by studies of human flight outside the atmosphere. When at last the new buildings began to rise at Brooks, the climate of opinion with respect to American leadership in exploring the universe would have suffered a dramatic reversal. It would be realized then that space medicine—a product mainly of the School—was the only area of cosmic research in which the United States could register a valid claim that it had been first with a large accumulation of useful knowledge.

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Chapter 14

ARRIVAL AT MATURITY

On February 8, 1953, at a meeting in Chicago, a body of men wielding almost unlimited power within their own domain handed down a decision that was to have a profound effect on the professional standing of the flight surgeon. After thirty-five years of apprenticeship, in the course of which its principles had spread to every nation of the world with an interest in the health and safety of people who travel by air, aviation medicine was at last accepted as a specialty by the American Medical Association.[1]

From its origin in 1917 as the study of a well-defined array of human infirmities, arising from the peculiar properties of the medium in which flying was conducted, aviation medicine had been regarded as a specialty by the physicians who practiced it. As early as 1929, in a resolution commending the Department of Commerce for the high standards upheld by its medical examiners, and in a letter forwarding the resolution to the White House, the American Medical Association itself had referred to aviation medicine as a specialty.

In fact, however, the specialized knowledge and experience required of the flight surgeon had received no formal recognition from that august assembly, which governed the practice of medicine in America. The reason for this oversight was implicit in the closely interwoven structure of the medical fraternity as a whole, created to protect the patient from quackery and incompetence.

To be accredited as a specialist in a recognized branch of medicine, the physician required a certificate granted by a board of outstanding practitioners in that field. It stated that he had completed a prescribed course of advanced study and practice under the tutelage of other specialists, had then been examined as to his knowledge and proficiency, and had been found qualified.

Both his academic studies and his supervised practice were to be accomplished in institutions approved specifically for that purpose by the Council on Medical Education and Hospitals of the American Medical Association. The examining board was a body approved by the Association through its Advisory Board for Medical Specialties.

In the case of aviation medicine, no formal course of training had yet been established in medical colleges and clinics approved for that purpose by the Council. Moreover, until now, no specialty board to define and maintain its professional standards had been accepted by the Advisory Board for Medical Specialties. In the official view of the American Medical Association, therefore, aviation medicine had not existed. Many of its practitioners were accredited specialists, but in some other field, such as internal medicine, ophthalmology, preventive medicine, or psychiatry.

The unusual circumstances in the development of aviation medicine, setting it apart from other specialties, was that it had been nurtured almost entirely in the military services. By this time, hundreds of qualified practitioners could be found in the aircraft industry, with the airlines, in agencies such as the Civil Aeronautics Administration, on the faculties of universities which gave some instruction on the medical problems of flight, and even in private institutions, like the Mayo Clinic or the Lovelace Foundation.

Without exception, however, they had received their training on active or Reserve duty with the armed forces. The only schools offering comprehensive courses in aviation medicine were those of the Air Force at Randolph and of the Navy at Pensacola. The only institutions providing specialized treatment facilities in which to practice were hospitals and dispensaries at air bases. The only certification granted for professional competence consisted of the wings awarded to military flight surgeons. These credentials meant little to the fellowship of medicine as a whole.

The possibility of creating a specialty board to administer standards of training and practice in aviation medicine had been raised at the annual meeting of the Aero Medical Association in 1940 by Dr. Louis H. Bauer, onetime commander of the Air Force School, then a heart specialist and consultant on aeromedical problems in Hempstead, New York. The Association had appointed a

committee to discuss the question with other professional organizations, including the American Medical Association.

At the next meeting, in 1941, Doctor Bauer had regretfully reported the opinion of the American Medical Association that there were quite enough specialty boards already. The committee had been advised that aviation medicine should apply to one of the existing boards for admission as a subspecialty. There the matter had rested for the next few years, while the second World War was under way in Europe and Asia.

At the 1947 meeting of the Aero Medical Association, General Grow had brought up the question again, suggesting that the Association should itself appoint a specialty board for aviation medicine, which then would ask for recognition by the American Medical Association. General Armstrong had bolstered this proposal by submitting a detailed plan for the formation of a Specialty Board Committee, which would recommend a course of action to the Aero Medical Association.

Armstrong's plan had been adopted. It had led in August 1949 to the appointment by the Association of an Interim Board of Aviation Medicine, authorized to take whatever steps might be necessary to gain recognition for the specialty by the American Medical Association.

The chairman of the Interim Board was General Benson. Among its members were Doctor Bauer; Captain Wilbur E. Kellum, a Navy flight surgeon and research specialist; Dr. Jan H. Tillisch of the Mayo Clinic, who had served on the wartime staff of the School at Randolph and was the Medical Director of Northwest Airlines; and Dr. Arnold D. Tuttle, commander of the School in the nineteen-thirties and now the Medical Director of United Air Lines. Before the work of the Board was finished, Doctor Tuttle would be dead of a heart attack.

Added to the Board later, as executive secretary, was another Air Force flight surgeon, Colonel Robert J. Benford, an editor of both the *Armed Forces Medical Journal* and *The Journal of Aviation Medicine*. Also added, as replacements for two of the original members who had resigned, were Dr. W. Randolph Lovelace II from the Lovelace Foundation in Albuquerque and Dr. Conrad Berens Jr.,

one of the last surviving founders of the Medical Research Laboratory at Hazelhurst, and now a notable eye specialist in New York City.

Thus the Interim Board was heavily weighted with physicians who had been associated with the Air Force School at one time or another. The obvious reason for this apparent favoritism was that few prominent specialists in aviation medicine could be found who had *not* been associated with the School in some capacity.

With characteristic energy and enthusiasm, General Benson had embarked on a campaign to secure recognition for the specialty from the American Medical Association. As his analytical mind had been quick to realize, the effort divided itself naturally into two parallel tasks. One was to form an alliance with a governing body which would be acceptable to the Advisory Board for Medical Specialties. The other was to develop a training program for the future that would satisfy the Council on Medical Education and Hospitals.

As to the first of these tasks, General Benson had taken the view of the Association as final that a totally new certifying board for aviation medicine would be redundant. In its place, he had proposed that one of the existing boards be invited to provide separately for certification in aviation medicine, as well as in the specialty for which it had been established.

The group selected to receive this invitation was the American Board of Preventive Medicine—the specialty most nearly resembling aviation medicine in its emphasis on measures to inhibit the growth of diseases arising out of environmental conditions. In the chairman of that Board, Dr. Walter L. Bierring, Commissioner of Health for the State of Iowa, and in its secretary-treasurer, Dr. Ernest L. Stebbins, Director of the Johns Hopkins University School of Hygiene and Public Health, General Benson had found two influential partners. They welcomed his overtures and were ready to coöperate with him in his plan.

Developing a formal training program for specialists in aviation medicine had taken a little more ingenuity. Up to this time, almost the only academic training available in the specialty had been the relatively brief introductory courses given by the School

at Randolph and the one at Pensacola. Virtually all of the flight surgeon's knowledge thereafter had been accumulated from personal experience with flying units in the field.

For two years, beginning in the fall of 1948, the Air Force School had offered an advanced course in aviation medicine, extending over the normal academic period of nine months. Designed for medical officers intending to make their careers in the specialty, it had lapsed after the graduation of the second class in the summer of 1950, mainly because of the pressing need for flight surgeons in Korea.

With the help of Doctor Bierring and Doctor Stebbins, in 1951 General Benson had instituted a similar course at the School, fitting it into a five-year program of specialized study and practice that was to qualify the student for Board certification. At the same time, as a second phase of the program, the School of Public Health at Johns Hopkins had inaugurated a one-year course for medical officers, leading to a degree as Master of Public Health. (This course was later to be offered by Harvard University and by the University of California at Berkeley, as well as by Johns Hopkins).

A third phase had been added in the fall of 1952, taking the form of a residency-type year of supervised practice under the guidance of the Tactical Air Command Surgeon at Langley Air Force Base, Virginia. (This phase also would be extended later to the Air Materiel Command Surgeon at Wright-Patterson Air Force Base, Ohio, to the School of Aviation Medicine itself, and to the future Manned Spacecraft Center of the still-to-be-conceived National Aeronautics and Space Administration, among other major organizations concerned with flying.)

The balance of the five years in training would comprise experience as a practicing flight surgeon, either before or after the candidate's formal entry into the program, at the Board's discretion.

Armed with these plans and agreements, General Benson had answered a call to appear in Chicago on February 7, 1953, before a joint meeting of the Advisory Board for Medical Specialties and the Council on Medical Education and Hospitals. With him, in

addition to the members of the Interim Board, was a panel of distinguished witnesses that included Doctor Bierring and Doctor Stebbins, General Armstrong, Dr. William R. Stovall (now Medical Director of the Civil Aeronanutics Administration), Rear Admiral Winfred P. Dana for the Navy's Bureau of Medicine and Surgery, and Brigadier General M. S. White, the Tactical Air Command Surgeon.

The professional lustre radiated by these eminent spokesmen for aviation medicine was in no way dimmed by the fact that one of them—Dr. Louis H. Bauer—had lately been elected President of the American Medical Association.

On the day after this meeting, the Advisory Board and the Council convened again in a closed session to consider the evidence which they had heard. This time their decision was favorable. Almost exactly on the thirty-fifth anniversary of the Laboratory at Hazelhurst, aviation medicine was officially pronounced a specialty.

Its work done, the Interim Board created by the Aero Medical Association disbanded. A place had now been created for General Benson on the American Board of Preventive Medicine, as vice chairman for aviation medicine. Dr. Jan H. Tillisch and Rear Admiral Bertram Groesbeck Jr. also joined the Board as members representing the new specialty. Their first responsibility would be to pass on the applications of those flight surgeons whose long experience would qualify them for immediate certification in the so-called "Founders Group," without any formal examination.

Less than three months later, on May 1, 1953, General Benson wound up his tour as commander of the School and went back to Washington with General Armstrong.[2] He was to be the Director of Medical Staffing and Education in the office of the Surgeon General. In that position, he would work closely with the Board of Preventive Medicine, formulating plans to expand and strengthen the specialty training program within the Air Force, and watching over the progress of younger officers who would come before the Board as future candidates for certification.

The Director whom he replaced at Air Force Headquarters also was the commander who relieved him at the School. Brigadier

General Edward James Kendricks was quite a different kind of leader, both in temperament and in methods, from either of his immediate predecessors. General Armstrong's bearing had been that of a scholar; General Benson's had been that of a brilliant and distinguished medical specialist. General Kendricks gave the impression of being exactly what he was: an accomplished military surgeon of the old school, erect and at ease in the uniform which he wore.

A contemporary of General Armstrong, from the town of Alpena in northeastern Michigan, General Kendricks had first seen the School of Aviation Medicine as a student medical officer in the fall of 1934. Three years afterwards he had returned to head the Department of Neuropsychiatry.

Summoned to the office of the Air Surgeon in Washington a few weeks after the attack on Pearl Harbor, General Kendricks had been appointed Surgeon of the 376th Bombardment Group, better known as "the Halverson Detachment" after its commander, Colonel Harry A. Halverson. In the utmost secrecy, Colonel Halverson's Group, flying B-24 Liberators, had been trained for a mission so dangerous as to be all but suicidal. It was to have bombed Tokyo from the mainland of China, complementing the carrier-based raid by Lieutenant Colonel James H. Doolittle.

In Khartoum, on its way to Burma, the Detachment had been diverted to the defense of North Africa against German Marshal Erwin Rommel's advancing armies. A few months later, it had been absorbed into the newly organized Ninth Air Force, with General Kendricks as Surgeon. Eventually, the Ninth Air Force had gone to Italy, then to England, and finally to Normandy, where it had become General Dwight D. Eisenhower's tactical air arm in Europe.

For his part in these campaigns, General Kendricks had been awarded—among other decorations—the coveted Soldier's Medal, rarely given to officers and then only for exceptional valor.

After the War, General Kendricks had gone to Wright-Patterson Air Force Base as commander of the Aero Medical Laboratory, filling the vacancy left by Doctor Lovelace. Since 1949, in the office of the Surgeon General, he had held the position which he now was exchanging for General Benson's at Randolph.

In spite of his past association with the School and the Laboratory, General Kendricks had never been identified with a personal preference for research or teaching over clinical practice or administration, as a good many medical officers had, among them General Armstrong and General Benson. His outstanding quality was a talent for command—the ability to mould and manage an organization so that it seemed to run smoothly on its own momentum, without close attention to its routine operations by the commander.

One key to this talent was the confidence that General Kendricks showed in delegating authority to his staff. In Washington, for the past four years, his Deputy Director had been Colonel John R. McGraw, who had brought the School of Air Evacuation to Randolph in the fall of 1944 and had served for some months on the staff of General Reinartz. Shortly after General Kendricks arrived at Randolph, Colonel McGraw joined him again as his deputy. On the strength of their close rapport in the past, Colonel McGraw was able to relieve General Kendricks of many minor actions and decisions, giving him the leisure to concentrate on questions of policy.

For the School as a whole, the effect of the change in command was to make the next few years an interlude of unaccustomed ease and tranquillity. It was lacking in the air of excitement—of great events impending—that had characterized General Benson's régime. But it was a period in which the work of the School was done with exceptional dispatch and in an atmosphere of unusual harmony.

The interlude was not long. In the first week of December 1955, after less than three years in command of the School, General Kendricks suffered a mild heart attack. He was admitted to the Base Hospital for a few weeks of rest and observation, and then released to continue his recuperation at home. There, on February 17, 1956, he experienced a massive and fatal coronary occlusion.

The General's body was flown to Washington for burial with military honors in Arlington National Cemetery. At the same hour, in the Chapel at Randolph Air Force Base, a memorial service was held for staff members and friends who could not attend the funeral in Arlington.

His death, at 56, was a source of keen regret to everyone who had been associated with him. General Kendricks had been highly respected both as an officer, with a firm belief in military honor and decorum, and as a physician, dedicated to the ideals of his profession. More than that, he had won the sincere affection of his colleagues by the warmth and humanity of his character.

Thanks to the spirit of individual and group initiative which he had inculcated in his staff, the School was able to carry on its work as usual during the spring of 1956, while the announcement of a new commander was awaited. As acting commander, Colonel McGraw continued to make decisions in accord with the policies that General Kendricks had outlined to him, as if the General had merely been away on leave or on a tour of inspection. After Colonel McGraw's departure in July, to become Surgeon of the Twelfth Air Force in Ramstein, Germany, Colonel Louis C. Kossuth was the acting commander.

The long delay in sending a replacement for General Kendricks was a result of a change in the disposition of senior medical officers throughout the Air Force. Two years earlier, in July 1954, General Armstrong had completed his term as Surgeon General, and had gone abroad once more to be the Surgeon of the United States Air Forces in Europe, with his office at Wiesbaden, Germany. Admirers of General Benson, noting the way in which his career thus far had paralleled General Armstrong's, had taken it for granted that he was to be the next Surgeon General.

But the Air Force Medical Service was a larger and more complex organization than it had been in 1949. The Surgeon General was responsible for so many more people, programs, and resources that it had become impractical for one executive—regardless of his brilliance or the breadth of his experience—to handle them all personally as General Grow and General Armstrong had done. Instead, the principle had evolved to divide these responsibilities among specialists, and to nominate as the Surgeon General a senior medical officer known best for his administrative skill and diplomacy.

General Benson was uniquely identified with the professional training and selection program. He was the sole representative of the Air Force on the American Board of Preventive Medicine.

He had been appointed a member of the House of Delegates by the American Medical Association. He was the President Elect of the Aero Medical Association. Paradoxically, these honors made him indispensable to the work in which he was then involved, whereas an officer whose talents had been exercised mainly within the Air Force was wanted as the Surgeon General.

So General Benson had continued as Director of Medical Staffing and Education. The choice of a Surgeon General to follow General Armstrong devolved upon Major General Dan C. Ogle, wartime Surgeon of the Fifteenth Air Force in Italy and General Armstrong's immediate predecessor as the Surgeon of the United States Air Forces in Europe. General Ogle was General Benson's senior by several years, was widely known in the Service and greatly esteemed by his associates.

After the death of General Kendricks, General Ogle had decided that the officer best qualified to succeed him at the School was General Benson, the same commander whom he had relieved only three years before. At Randolph, General Benson would still be free to carry on his duties on the Board of Preventive Medicine, as a delegate to the American Medical Association, and as a past President and active Fellow of the Aero Medical Association. Orders confirming the appointment were published in May 1956.

But General Benson still had business to wind up in the Surgeon General's office. So the School had to get along for several more months without a permanent commander. It was late in August before General Benson arrived at Randolph and took over his command formally for the second time.[3] Almost immediately, it was as if he had never gone away, and the past three years had been a drowsy summer afternoon's reverie.

Few changes had occurred in his absence. Colonel Frederick J. Frese Jr., his former deputy, had been reassigned nominally to Air University Headquarters and relieved of other tasks, so that he could give his full time to detailed plans for the Aeromedical Center. But his duty station still was the School at Randolph.

Colonel Paul Campbell had departed for London in the summer of 1953, as Medical Air Attaché. The Director of Research now was Colonel Henry M. Sweeney, who had worked for General

Benson during the first months of the War as a high-altitude physiologist of great energy and distinction at the Aero Medical Laboratory in Dayton.

Of the German scientists who had revitalized the research staff at the close of the War, only seven remained. Several had returned to continue their careers in Germany, as economic conditions there had improved. But the overwhelming majority had been attracted by positions offering higher salaries and more authority at universities and other institutions in the United States.

Dr. Ulrich C. Luft had gone to the Lovelace Foundation in Albuquerque as Director of Research; Dr. Paul Cibis to the Washington University Medical School in St. Louis, and eventually to a prosperous clinic of his own; Dr. Werner K. Noell was at the University of Buffalo, New York; Dr. Jürgen Tonndorf at Iowa State University; Dr. Ingeborg Schmidt at Indiana University in Bloomington.

Of the original members of the Department of Space Medicine, Doctor Strughold alone was left, with a young Air Force medical officer and a civilian physician as assistants. Dr. Heinz Haber had moved to the University of California at Los Angeles, on his way back to Germany as a television producer and publisher of a magazine devoted to science; Dr. Fritz Haber was an executive with the Avco Corporation in Connecticut; Dr. Konrad Buettner a professor at the University of Washington in Seattle.

The six German specialists still at the School, besides Doctor Strughold, were his former deputy, Dr. Hans-Georg Clamann, and Dr. Bruno Balke, both in Physiology; Dr. Heinrich W. Rose and Dr. Siegfried J. Gerathewohl in Ophthalmology; and Dr. Herbert B. Gerstner and Dr. Oskar L. Ritter in Radiobiology. Eventually they would be reduced to Doctor Strughold, Doctor Clamann, and Doctor Ritter.

Despite the loss of so many irreplaceable scientists from abroad, the staff had continued to grow. The total strength of the School at Randolph now had surpassed its wartime peak, and stood at approximately 575 military and civilian specialists and technicians. Some 435 more were assigned to the branch at Gunter Air Force

Base, Alabama, waiting for the Aeromedical Center to be established. General Benson's command had by no means diminished in size or consequence under General Kendricks.

Six weeks after his return, on October 11, 1956, General Benson arose from a meeting with his staff, walked into his office, and there suffered a heart attack, more severe than the one which had first overcome General Kendricks. He was isolated in the Hospital while a battery of cardiologists studied his condition and gave cautious prognoses for its outcome.

In the next few weeks, it became apparent that the damaged muscle was repairing itself. Like President Eisenhower and like Senate Majority Leader Lyndon Johnson, he would make a full recovery unless another more serious setback occurred.

By the end of November, he was released to his quarters to complete his convalescence, with the assurance of his physicians that he could expect to return to his duty within another month or so.

While he was still hospitalized, late in October, General Benson received word from Washington that he had been promoted to Major General. He thus became one of only five medical officers in the Air Force to wear two stars—a company that included General Armstrong and General Ogle—and the first commander of the School to hold that rank.

His elevation was not only in recognition of his own services to aviation medicine. Also it was a tacit acknowledgement that command of the School at Randolph now had become one of the major assignments in the Medical Service, equal in authority to the positions of the Surgeon General and the Surgeon of the United States Air Forces in Europe.

As if to emphasize this point, in October also the Air Force finally released a total of $8,800,000 in appropriated funds to begin construction of the new headquarters for the School at Brooks Air Force Base.[4] Bids for the project were advertised by the Galveston District of the Army Engineers in December. The bids were to be opened and a contract awarded in March 1957.

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Chapter 15

TRAVELS IN THE LABORATORY

The same outburst of creative energy that brought so much attention to the School of Aviation Medicine in the nineteen-fifties also brought a fundamental change in the character of the space research conducted there. From a largely theoretical inquiry, seeking to define the problems which the future astronaut would face, it became a subject of practical experiments, designed to give at least tentative solutions to the problems.

In this respect, space medicine followed much the same course that aviation medicine had taken some thirty-five years earlier. Moreover, it led to much the same result: that knowledge of the flyer's biological needs and responses in space temporarily outstripped the engineer's ability to send him there.

The single piece of experimental equipment which did the most to bring about this change was an apparatus known to its designers as a space cabin simulator, or simply as a space cabin.[1] Closely resembling one of the early pressure chambers developed by the Laboratory at Hazelhurst, it offered the same advantages to the research physiologist. It was a stable test compartment, fully under the control of the investigator, in which many of the medical problems arising on a lengthy flight beyond the atmosphere—though by no means all of them—could be duplicated in the laboratory without ever leaving the ground.

The space cabin evolved naturally from the analysis of the difficulties confronting a flyer in space, as they had been summarized in the paper, "Where Does Space Begin?" If the astronaut, beginning at an altitude of only 12 miles, required a habitation with its own self-renewing planetary environment, sealed off from the ambient air, and would require the same protection until he returned to the atmosphere from his sortie into space, then the

logical starting point for a study of the problems he would encounter was the construction and equipment of the habitation itself.

The space cabin was conceived by Doctor Strughold and his associates early in 1952. The engineering plans and specifications were drawn by Doctor Fritz Haber, who was an aircraft designer. A contract for the steel shell was given to the Guardite Corporation of Chicago, one of the principal fabricators of pressure chambers. It was delivered to the School at Randolph in the late summer of 1954.

In spite of its resemblance to a small pressure chamber, the principle embodied in the space cabin was basically different. Whereas the pressure chamber reproduced the natural characteristics of the medium outside the cabin—the upper levels of the atmosphere or space—the cabin represented an artificial environment, sealed off from the natural medium outside, in which the crew was protected from the surrounding void during the flight. It was, so to speak, a miniature sample of the planetary environment from which the travelers had come. In that respect, it was a laboratory equivalent of the gondola in which Captains Anderson and Stevens had invaded the stratosphere with *Explorer II*, or the capsule in which Doctor Henry had enclosed his mice and his monkey for their trip aloft in the Aerobee rocket.

For engineering reasons, having to do with the weight and strength of the cabin structure which the booster rocket would have to carry into orbit, it was considered impractical to provide the crew with a normal atmosphere under the full pressure of the Earth's air at sea level (760 mm Hg). Instead, the aim was to maintain an interior pressure of half an atmosphere (380 mm Hg), matching the pressure of the ambient air at an altitude of about 18,000 feet, or 3 4 miles.

But since the normal amount of oxygen obtained from the air at sea level (a partial pressure of approximately 160 mm Hg) was essential to the health and efficiency of the flyer, the concentration of oxygen would be doubled, to a partial pressure of about 320 mm Hg. Among the uncertainties arising with the higher concentration of oxygen were its possible effects on the respiratory system over a period of days or weeks and the extent to which it

might increase the fire hazard from a random spark or a short circuit in the cabin's wiring or equipment.

These were not the only questions that could be resolved in advance by experiments in the space cabin. Various methods of removing excess carbon dioxide and other human wastes and toxic gases from the air were to be compared. Systems to control temperature and humidity were to be tested. Ways to recycle fluids from the body, to provide fresh water, were to be examined. Adequate food supplies in concentrated form, requiring minimum space for storage, were to be developed. The effects of isolation and confinement were to be studied. Favorable work-rest-sleep schedules were to be explored.

In fact, useful information on nearly all the human problems of space flight could be gained from experiments in the space cabin, with a few notable exceptions. They would provide no data on the effects of long-continued weightlessness, or on exposure to cosmic and solar radiations, or on emergency procedures if the space craft should be damaged and the crew had to be rescued and brought back to Earth. These were problems for which no practical solutions could be worked out in a laboratory on the ground.

When the space cabin arrived at Randolph in August 1954, Doctor Strughold was abroad, attending a series of international meetings. His associates in the Department of Space Medicine already had left the School for more attractive positions elsewhere, and had not yet been replaced. Dr. Hans-George Clamann took charge of the cabin and set it up in the basement laboratory of the Department of Physiology and Biophysics. With his own assistant, Dr. Richard W. Bancroft (an enlisted technician at the School in World War II, who had later taken his Ph.D. degree in physiology and had returned to be a research scientist), Doctor Clamann undertook the task of testing and equipping the cabin and planning its instrumentation.

Like the first pressure chamber, the space cabin was small. The 96 cubic feet which it enclosed allowed barely room enough for one man sitting up, surrounded by monitoring and test devices, and less than enough room for him to recline during an experiment lasting for several days. But the compartment was fitted with an

air lock at its entrance. By removing the inner hatch and extending the subject's feet into this area, he could be given just enough additional space in which to rest or sleep.

Another small air lock was provided at the rear of the cabin. Through this narrow passage, food and other supplies could be passed to the subject without opening the main hatch and thus interrupting the experiment. Five small observation ports were placed at intervals around the cabin wall. During simulated flights, they could be covered to increase the subject's impression of isolation and detachment from the ground.

The cabin at first was plagued with air leaks and other technical difficulties. By the time these were solved, in the spring of 1956, Doctor Strughold had acquired as assistants two young doctors of medicine: James G. Gaume, who had given up his private practice to join the Department of Space Medicine, and Captain Emanuel M. Roth, a recent graduate of the Primary Course in Aviation Medicine.

Early in April 1956, they ran the first 24-hour test of the cabin—comparable to about sixteen orbits around the Earth in a space craft—with a youthful airman as the subject. More technical difficulties developed in the equipment, but the test was completed successfully. For the next few months, while Doctors Gaume and Roth were refining the life-support systems, only brief tests of 2 to 6 hours were run. The next full-scale test of 24 hours followed in October 1956. Again it showed a need for additions and improvements in the equipment, although the simulated flight itself was a success.

A full year went by before the next 24-hour test in October 1957. During that interval, the Department of Space Medicine was reorganized and enlarged. Doctor Strughold, whose métier for many years—both in Germany and at Randolph—had been that of a creative thinker, originating new concepts which were then applied experimentally by younger scientists under his direction, was reassigned to General Benson's staff as Advisor for Research, the same position which he had once held under General Armstrong.

The new head of the Department was Lieutenant Colonel George R. Steinkamp, a flight surgeon who had formerly been a specialist

on rescue and survival procedures for air crews of the Strategic Air Command. Among his assistants were Captain Julian E. Ward (later killed in the crash of an L-20 aircraft on a local flight out of Spangdahlem, Germany); Dr. Siegfried J. Gerathewohl, from the Department of Ophthalmology; and George T. Hauty, Ph.D., a psychologist. Medical officers from other departments joined Colonel Steinkamp now and again to participate in tests.

The cabin had been removed from the basement under the Headquarters Building to a more spacious laboratory in a temporary structure some distance away. There it had accumulated an elaborate collection of specialized devices for monitoring and control of experiments, including instruments to record the subject's physiological functions, electronic boards (recalling the banks of flashing lights on the Complex Coördinator during the nineteen-thirties) to show his ability at solving tests similar to those which an astronaut would have been called upon to perform in flight, and closed-circuit television receivers to observe his behavior while he was isolated in the cabin.

The last 24-hour run, on October 18-19, 1957, was planned primarily to test the performance of these devices. It was to be followed by a seven-day experiment in February 1958, simulating a flight to the distance of the Moon and back.

In spite of the science-fiction atmosphere which the space cabin sometimes evoked in news correspondents and other casual visitors to the laboratory, its eventual importance in manned space operations should not be minimized or overlooked. Because of this complicated piece of non-flying apparatus, the basic principles of life support and communication in an orbital space craft would have been determined, tested, and found to work by the time the United States was ready to send its first astronaut aloft. The result would be to save many months of research and testing in the development of the space craft itself.

Other practical experiments in space biology, some of them even more far-sighted than the tests in the space cabin, were carried on by the School in the nineteen-fifties. One was closely related to the design and operation of the cabin. It was the search for a system to remove waste carbon dioxide from the cabin air, and replace it with fresh oxygen, by the natural process which

occurs continually in the Earth's atmosphere: photosynthesis within the cells of living green plants.[2]

On relatively brief flights in space, lasting a few days or a few weeks, the simplest and most economical way to renew the air in the cabin was by chemical and mechanical means. Chemicals were used to absorb excess carbon dioxide exhaled by the crew as a product of metabolism, while additional oxygen to replace it was released from tanks or cylinders in which the life-giving gas was stored as a liquid, chilled to a very low temperature and kept under pressure until it was needed.

But on long expeditions, extending over several months or years, or in bases on planetary bodies like the Moon, which were deficient or totally lacking in atmospheric oxygen, the bulk and weight of these storage systems would become a critical logistic problem. Besides, there was the danger that the oxygen might be lost by leakage or by some other catastrophe, leaving the crew at a great distance from the Earth and without any source from which to replace it.

At the 1951 Symposium, Dr. Heinz Specht of the National Institutes of Health had suggested that this problem might conceivably be solved by growing cultures of green water plants such as algae inside the cabin. The great virtue of algae was that they grew fast and were highly efficient in converting carbon dioxide—which plants used in their own metabolism—into oxygen and carbohydrates. The carbohydrates were employed to build the cellular structure of the plants, while oxygen was released into the atmosphere again.

The Department of Space Medicine had looked around for an authority on plant physiology to investigate this possibility, and had found one only sixty miles or so away in Dr. Jack Myers, Professor of Zoology at the University of Texas in Austin. Already noted for his work on algae as a potential source of food for the world's fast-growing populations, Doctor Myers had undertaken a study to determine their utility as a biological means of gas exchange in a space cabin.

By 1954, Doctor Myers had shown that it was indeed possible to build a closed biological system in which algae, suspended in a nutrient solution and exposed to a source of light, would absorb

the excess carbon dioxide exhaled by a small animal, such as a mouse, and would release enough oxygen to sustain the animal's vital activities.

Carrying on from there in its own laboratories, the School of Aviation Medicine had developed progressively larger systems, capable of maintaining one or more crew members on an extended trip in space. At the same time, the systems had been refined to increase their efficiency, thereby reducing their weight and bulk, to the point where they would become practical as a self-perpetuating source of oxygen (and incidentally of a dietary food supplement as they were harvested) in space craft of the future.

Equally far-seeing, or more so, was another laboratory experiment carried on by the School. It was an attempt to simulate the atmospheric and climatic conditions on the surface of Mars, in order to learn whether elementary forms of life such as bacteria could survive there.[3] In all probability, this was the first practical experiment in the field that would be known later as "exobiology," the study of extraterrestrial life in the varied environments found elsewhere in the Solar System.

Since the beginning of space medicine, one of Doctor Strughold's prime interests had been the possibility that life of some variety recognizeable on Earth might exist on neighboring planets, either as an indigenous development or by transfer from a more favorable environment. In a series of papers, he had narrowed the search to Mars and Venus, concentrating especially on Mars because of the difficulty in determining what the surface conditions on Venus were, under its dense and opaque cloud cover. In 1953, Doctor Strughold had published a book about Mars from the point of view of the physiologist, *The Green and Red Planet*, summing up the data which he had accumulated at that time. In this book, he had suggested the feasibility of using pressure chambers to reproduce the surface conditions on Mars and other planets in the laboratory.

In the summer of 1956, a young lieutenant in the Department of Microbiology, John A. Kooistra Jr., had induced the department head, Dr. Roland B. Mitchell, to let him follow up Doctor Strughold's suggestion. Instead of a pressure chamber, he used a set of large glass laboratory jars from which the air was exhausted

and its constituents altered to match the surface atmosphere on Mars, as it was then identified from astronomical observations.

With the active coöperation of Doctor Mitchell and others in the Department, Lieutenant Kooistra found an arid soil in the deserts of the Southwest that closely resembled the kind of soil believed to exist on Mars. In this he deposited cultures of native bacteria from the same area, with mere traces of water as it might be obtained from the periodic melting of the polar ice caps on Mars. The diurnal range of temperatures on Mars (which has a day only a few minutes longer than the Earth's) was reproduced simply by placing the jars in a refrigerator overnight and letting them warm up to room temperature in the air-conditioned laboratory during the day. As with the space cabin, the principal conditions which could not be matched were the reduced gravitational attraction on the surface of Mars and the increased exposure to cosmic radiation under the very thin atmosphere of that planet.

At a symposium of the International Mars Committee and the Astronomical Society of the Pacific in Flagstaff, Arizona, on June 15, 1957, the first results of this experiment were presented in a joint paper by Lieutenant Kooistra, Doctor Mitchell, and Doctor Strughold. (The paper was published later in the *Journal* of the Society.) The most impressive finding was that certain types of bacteria not only survived but multiplied under the rigorous climatic conditions of the simulated Martian environment.

One more of these experimental programs should be mentioned, because of the influence which it was to exert on space research in the nineteen-fifties and later. Soon after the arrival of Dr. Fritz Haber at the School in 1949, he had joined his brother Heinz in working out a technique to produce brief periods of weightlessness for aeromedical research—not in a laboratory on the ground, to be sure, but in the atmosphere only a few miles above it.[4] First presented at the annual meeting of the Aero Medical Association in the spring of 1950, and later published in *The Journal of Aviation Medicine,* this technique attracted wide interest among test pilots and research scientists with a taste for flying.

In essence, this method was to reproduce, in a jet airplane, the same parabolic flight path which a rocket craft covered at the top of its trajectory, before it coasted back to Earth. Starting

at a considerable height, the jet would dive and then pull up into a series of arcs resembling the course of a roller-coaster. Near the high point of each arc, the pilot and his observor would be subject to diminished gravity, and at the high point for a few seconds, varying with the initial speed of the craft, they would be weightless, exactly as if they were in orbit.

During 1951, the technique was tried at Edwards Air Force Base by Scott Crossfield of the National Advisory Committee for Aeronautics and by Air Force Major Charles E. Yeager, among others, and at Wright-Patterson Air Force Base by Captain Edwin R. Ballinger, a medical officer associated with Dr. James P. Henry of the Aero Medical Laboratory. They reported some disorientation when they first experienced weightlessness, but their initial confusion left them as they grew accustomed to the sensation, and was often followed by a feeling of ease and even of exhilaration.

Still the suspicion persisted among many physicians that long-continued weightlessness in orbital space craft must be associated with physiological or psychological disturbances of some severity, if only in subjects with a predisposition to orientational difficuties. It was felt that the effects ought to be thoroughly explored before the first astronauts were catapulted into space. The School of Aviation Medicine was ready to undertake this research.

But the School had no jet airplanes of its own. Its only aircraft in the early nineteen-fifties were four converted wartime B-25 bombers, two C-47 transports, and a B-17, used for travel by the command and staff, to carry supplies, for flight familiarization of student medical officers, and occasionally in research. Since the School no longer was a part of the Air Training Command, Randolph was under no obligation to place one of its jets at the scientists' disposal.

In the spring of 1955, Air University Headquarters finally sent the School a T-33A jet trainer in exchange for one of the C-47s. (Later, it was replaced by an F-94C Starfire jet fighter, and eventually by an F-104B all-weather interceptor.) In these aircraft, flying Keplerian trajectories, it was possible to obtain periods of zero and near-zero gravity ranging from about 15 seconds up to a minute and a half.

With Major Herbert D. Stallings Jr., director of Flight Operations, as his chief pilot and collaborator, Dr. Siegfried J. Gerathewohl (a wartime glider pilot himself, as well as a psychologist with a strong interest in physiological responses of the sensory and perceptual systems) set to work with energy and zest to collect observations on the reactions of animals and human subjects to the sensation of weightlessness. In the next year or two, he made several hundred flights, averaging about ten individual parabolas on each flight and recorded the responses of a hundred or more other subjects to a variety of psychomotor tests during zero gravity. His findings were reported in a series of papers presented at meetings in the United States or abroad, and later published in scientific journals.

Some experiments by Doctor Gerathewohl were both ingenious and spectacular, as when he rigged cameras in the observer's cockpit of a jet fighter, to show the behavior of a kitten floating in the air under the canopy during weightlessness. (The kitten was unable to right herself in order to land on her feet, as she would have done instinctively had she been actually falling.)

Nevertheless, Doctor Gerathewohl's results were inconclusive, as previous tests of an informal type by pilots like Crossfield and Yeager had been. About all they indicated was that animals and some non-flyers were readily confused by the experience, while trained pilots, flight surgeons, and aircraft observors usually adapted themselves to it without difficulty, relying on visual cues for orientation when the customary sensory ones were missing. The only firm conclusions derived from the tests were that a few seconds of weightlessness in the air would not suffice to determine the possible effects over a long period in orbit, and that astronauts would need to be given some training in jets flying weightless parabolas before they went aloft for the first time in space craft.

The School of Aviation Medicine was not the only institution conducting experiments to prepare the flyer for conditions in space. At the Aero Medical Laboratory in Dayton, the early pressure suit was refined to give full protection in space for a longer time; studies of space nutrition were launched, to provide the future astronaut with a diet of minimum bulk and weight during orbital flight; tests showing the effects of acceleration in various bodily positions were carried out on the human centrifuge; and periodic

meetings were held to discuss the difficult question of escape and rescue operations to retrieve an astronaut stranded in a damaged craft at a distance of a hundred miles or mc ɔ in space.[5] Both there and at the School, progress was made in developing instruments to monitor the astronaut's condition during orbital missions from tracking stations on the ground by radio telemetry.

At Holloman Air Force Base, the Aeromedical Field Laboratory now was under the command of Lieutenant Colonel John Paul Stap,, who had been Captain Yeager's flight surgeon when he had pierced the sound barrier for the first time a few years earlier. There, in December 1954, riding a rocket-propelled sled on a track almost seven miles long, with water brakes to bring it to a quick halt, Colonel Stapp attained a speed of 638.86 miles per hour to become known as "the fastest man on Earth," surviving a deceleration force 40 times the normal attraction of gravity at the end of his run.[6] The object of the test was to show that the astronaut, properly positioned and protected, could endure the sudden impact of his craft with the atmosphere on his re-entry from space.

Another medical officer from Holloman, Major David G. Simons, who had been the field director of Doctor Henry's rocket tests with animals some years before, achieved a record of another kind in the late summer of 1957. On August 19, in an aluminum capsule embodying the latest life-support and monitoring systems developed at the School and elsewhere, suspended under a helium-filled balloon, Doctor Simons soared to an altitude of 19.2 miles above an iron-ore quarry near Crosby, Montana.[7]

The purpose of the 32-hour flight of *Manhigh II* was not only to evaluate the biological support systems in the capsule. Also—and more importantly—it was to assess the potential hazard from prolonged exposure to cosmic radiation in a vehicle raised above all but a minute fraction (about 1.05 per cent) of the protective cover afforded by the Earth's atmosphere, as an orbiting space craft would be. As it turned out, the hazard was found to be negligible.

The net effect of all these programs—and many others like them—was to place the United States by the autumn of 1957 in a position where it possessed the medical knowledge to sustain an astronaut in space for at least 24 hours, and to bring him down

safely if no unforeseen technical failure of the craft occurred. Now all that was needed was a vehicle of sufficient power, with adequate guidance and communication equipment, to carry him up to the requisite height at the velocity necessary to keep him there, circling the Earth until he was ready to return. And in fact this vehicle was now in sight.

The autumn of 1957, the Atlas intercontinental ballistic missile was approaching operational readiness.[8] Its development had gone faster than the Air Research and Development Command had expected. There remained only to complete the cycle of test launches, adding refinements to successive models, and finally to turn the complete system over to the Strategic Air Command for installation at sites around the country. A good many of ARDC's engineering brains now were free to consider applications of the Atlas booster as a launching vehicle for manned space craft.

During 1957, and again in 1958, Brigadier General Don Flickinger (now Surgeon of the Air Research and Development Command) brought teams of engineers and medical officers from within the Command to Randolph for consultation with the Department of Space Medicine on what was then a highly secret program with the code name, "Man in Space." It was a tentative plan to orbit a space craft of minimum size, carrying one or at most two men, riding what would normally have been the re-entry nose cone of an Atlas booster.

From several alternate designs, ARDC had been leaning toward a conical one, resembling an inverted funnel, as the most practical. It would provide a broad base for the heat shield, which was to absorb the extremely high temperature developed by friction with the denser air below as the craft was braking for its descent into the atmosphere. A parachute system then would deploy automatically and lower the craft gently to a landing on the ground or on the ocean.

The project was an exciting one, and the School was confident that it could be carried off without harm to the astronaut. But the "Man in Space" program was not to be realized by the Air Force. Only seven weeks after the return of Doctor Simons from his record-breaking balloon flight, an event occurred on the other side of the world that was to change the whole character of American space programs.

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Chapter 16

LIFE IN ORBIT

An hour or so before midnight on the evening of October 4, 1957, at the village of Baykonur, northeast of Aralsk on the desolate Kirghiz steppes of Kazakhstan, in western Asia, the first artificial Earth satellite ever orbited by human hands was launched into space by scientists and engineers of the Soviet Union Air Force.[1]

Authorities in Moscow waited several hours until they were sure that the shot had been a success. Then, early in the morning of October 5 (while it was still the cocktail hour of the night before in Washington), they announced their achievement to the world's press.

Sputnik I's altitude ranged from about 140 miles to about 590 miles above the ground. It had been launched in a northeasterly direction from Baykonur, over one of the two Soviet test ranges for ballistic missiles (the other was at Kapustin Yar, several hundred miles west, in the neighborhood of Stalingrad), in a semi-polar orbit inclined about 65° to the Equator. Thus it returned to its starting latitude every 96.2 minutes at a point roughly 1,100 miles west of its previous position, the distance which the surface of the Earth had revolved during its orbit. In the course of a day, Sputnik I would pass over every major city of every large country on every continent of the globe, emitting its characteristic "beep-beep" signal as a reminder that it was there.

It traveled across the sky above Washington and New York City for the first time about half an hour before midnight on the evening of October 4.

The opening of the Space Age on the steppes of Asia was a stunning surprise to most Americans. Until now, it had simply

not occurred to them that the Soviet Union might have the scientific knowledge, the technical skill, or the industrial resources to bring off such a feat. Either they had not realized or they had forgotten that a provincial Russian schoolteacher, Konstantin Eduardovitch Ziolkovsky, before World War I, had been among the first theoreticians to deduce the techniques and mechanics of space flight, and that the Soviet occupation forces in Germany at the end of World War II had been as zealous as the Americans in tracking down rocket scientists and engineers for service in their own research laboratories.[2]

Since World War, II, the United States had laid aside plans for the development of satellites and space craft, to concentrate on long-range ballistic missiles. The Soviet Union obviously had found it worth while to develop both. At the same time that they were building a rocket booster considerably larger and more powerful than Atlas to launch their missiles, they had also designed and built space craft which the same booster could carry into orbit, with the necessary instruments for guidance and communication. It was evident that Soviet leaders considered both tasks to be facets of the same effort. The Soviet air arm was responsible for both. They used the same test facilities, launching sites, and tracking stations.

The immediate result of the Soviet exploit was to arouse the press, the Congress, and the public to a debate as sharp as the one which had led to the organization of the Air Force as a separate branch of the Defense Department after World War II. This time the question was how to retrieve the nation's lost leadership in space exploration, and whether the program should be undertaken by the Army (which had the most illustrious team of rocket engineers in Dr. Wernher von Braun and his compatriots from Peenemünde) or by the Navy or the Air Force.

Both the Army and the Navy had been planning to launch experimental satellites packed with scientific instruments in the next few months, as a feature of American participation in the observance of the International Geophysical Year. The Air Force had no such program on its calendar. In any case, the Soviet Union had left them all behind. Its satellite already was aloft, beeping hoarsely as it streaked across the sky.

A month later, while the United States still waited for its first satellite launching, the Soviet Union repeated its October triumph on an even more impressive scale. On November 3, 1957, from the same remote site deep in Asia, it lofted a second satellite into nearly the same orbit, except that the distance at apogee was greater. This time the space craft weighed more than half a ton, compared with the 185 pounds of Sputnik I. Also it carried a passenger: a female dog named Laika, supplied with life-support systems to sustain her vital functions for a week or longer, and fitted with automatic instruments with which to monitor her condition.

After the systems failed, Laika's body was not returned to the ground. Instead, she was left to circle in the space craft for several more months, until the orbit decayed and the craft was vaporized like a meteor in a flash of light as it plunged back into the atmosphere. Her seven-day flight was a clear sign that the Soviet program was designed not merely to gather scientific data by sending instrumented vehicles aloft. Instead, its aim was to prepare the way for human flight in space within the next few years, and ultimately no doubt to land human beings on the Moon and other planets. The Soviet space effort as a whole went far beyond any plans which the United States had considered seriously until now.

One month after Sputnik 2, on December 6, 1957, the United States made its first attempt to place an experimental satellite in orbit. The rocket booster was the Navy Vanguard, carrying a 3-pound package of instruments. The shot was a fizzle. In full view of a national television audience, after burning for two seconds, the booster lost its thrust and the vehicle was destroyed.

Not until the last day of January was the first American satellite orbited successfully. The booster this time was the Army's Jupiter C rocket, an outgrowth of the Air Force Navajo program, developed by Dr. Wernher von Braun and his team. It carried a payload weighing 31 pounds, crammed with cunningly miniaturized instruments, called Explorer 1. Regarded as only a modest success at the time, it was to transmit data back to the ground for nearly four months and give Dr. James A. Van Allen his first glimpse of the twin belts of solar radiation caught in the Earth's magnetic field just above the last vestiges of the atmosphere.

Against this background of apparent futility in the American effort to overtake the commanding lead of the Soviet Union in space operations, the School of Aviation Medicine went ahead with its plan to test the space cabin and its life-support systems in a simulated flight of seven days.[3] The experiment was scheduled to begin on February 9, only a week after the successful launching of Explorer I. Colonel Steinkamp and his colleagues in the Department of Space Medicine had conducted an exhaustive series of physiological and psychological examinations to select the subject. Their choice was Donald G. Farrell, a personable, 23-year-old airman from The Bronx in New York City.

Much to the surprise of the Department—and rather to its dismay—the experiment turned out to be a popular attraction dwarfing even the scale of the 1951 Symposium. The obvious reason was that the United States then had only one success in space activities—Explorer 1, an achievement the full extent of which was not yet realized—to set against the spectacular flights of the two Soviet Sputniks. The space cabin was a tangible piece of scientific apparatus, albeit a non-flying one. Its occupant, Airman Farrell, offered the potential human appeal that later would be found in the first astronauts. For want of a real expedition into space by an American flyer, the press turned to the imaginary one scheduled at Randolph.

The first indication of the widespread coverage to come was a page 1 article by William G. Smith in *The Wall Street Journal* early in December 1957, describing the test and its significance. By February, when the experiment began, the visiting press included the television networks with their camera crews from New York City, the wire services, photographic agencies, and reporters for a score of metropolitan newspapers in the United States and abroad. It had become necessary to set up a news room with a dozen or more individual telephone lines adjacent to the Information Office in Stafford Hall, the building back of the School's Headquarters. On-the-spot interviews with the medical officers and scientists monitoring the experiment had to be rationed on a strict schedule each day, in order not to interfere with the conduct of the test itself, thus compromising the validity of the results.

On the final morning, February 16, when Farrell emerged from the cabin as it returned to ground-level pressure, Senate Majority

Leader Lyndon B. Johnson was waiting outside the hatch to greet him in the Laboratory, while rows of cameras recorded the event. After a routine post-flight examination, the young airman joined Senator Johnson, General Benson, Doctor Strughold, Colonel Steinkamp, and others at a formal press conference in the main auditorium of the School. From the press conference, Farrell was flown to New York City for a round of appearances on television programs, and from there to Washington as one of the guests of honor at a meeting of the Air Force Association with the Secretary of the Air Force, the Chief of Staff, and other notables.

The Air Force naturally was hoping that the enormous amount of press coverage given to the space-cabin experiment at Randolph would bolster its claim to be the agency most qualified by experience and technical knowledge to manage the American program for the exploration of space. But the Farrell experiment was a brief sensation—a seven-day wonder—and was quickly forgotten as the actual satellite launchings multiplied and the controversy over the direction of the American space effort continued in Washington.

By the end of June, both of the original Soviet Sputniks had decayed and fallen back into the atmosphere, to flare up in momentary bursts of flame and vanish. But Sputnik 3, weighing almost a ton and a half, had followed them into orbit, where it would remain for the next two years, transmitting data back to the ground.

In the United States, the Navy had lost four more Vanguards by failures in launching, while the Army had lost its second Explorer from the same cause. But one Vanguard and the third Explorer had orbited successfully, giving the United States three small satellites with advanced instrumentation to the Soviet Union's one massive Sputnik of unknown capability in returning scientific data.

On July 29, 1958, the debate over the management of the American space program was ended when the Congress passed, and President Eisenhower signed, Public Law No. 85-568, the National Aeronautics and Space Act.[4] The measure had been drafted under Senator Johnson's supervision to conform with the President's wishes, and it was a masterly example of political compromise.

Neither the Army, the Navy, nor the Air Force was to manage the American space effort. Instead, it was to be directed by a new civilian agency, the National Aeronautics and Space Administration (NASA), created for that purpose and responsible directly to the President.

The preamble to the Act was a statement emphasizing the nonmilitary character of the program and the reason why it had been entrusted to a civilian organization. The statement read: "The Congress hereby declares that it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind." For that idealistic reason, it had been deliberately divorced from military research and development, unlike the Soviet space program.

The Act went on to specify the powers granted to the new agency: "The Congress declares that . . . aeronautical and space activities . . . shall be the responsibility of, and shall be directed by, a civilian agency exercising control over aeronautical and space activities sponsored by the United States. . . ." NASA was authorized to take over and administer any scientific space plans or systems then under development by the military services, and to draw on the facilities, resources, personnel, and services of the armed forces as it might deem necessary to carry out its own aims and programs. One of NASA's early moves, in its rapid expansion to the size and status of a major executive department, was to acquire from the Army the facilities and personnel of Dr. Wernher von Braun's missile research and development organization at Huntsville, Alabama.

The Act specified that "activities peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States . . . shall be the responsibility of, and shall be directed by, the Department of Defense." But the burden of justifying these programs rested on the Department of Defense. It was the obvious expectation of the Act's drafters that no military space programs would be needed for some years to come, if indeed ever.

The vast theatre of operations reaching out indefinitely into the cosmos was viewed as a neutral zone, exempt from either the machinations of the Cold War or preparations for the possibility

of a nuclear conflict in the future, and reserved solely for the nonbelligerent rivalry—and perhaps, later on, coöperation—between scientists of the United States and of the Soviet Union.

The nucleus of the National Aeronautics and Space Administration was the old and honored National Advisory Committee for Aeronautics, created by an earlier Act of Congress to assist other agencies concerned with flying—including the airlines, aircraft manufacturers, and the Civil Aeronautics Administration, as well as the military services—in developing and testing new flight systems and devices to promote flight safety.[5] The Committee had been established in 1916. Thus NASA could claim antecedents a year or two older than the School of Aviation Medicine.

Except for the Administrator, appointed by the President, the management of NASA came from this predecessor organization. The first Administrator was the Honorable T. Keith Glennan, President of the Case Institute of Technology in Cleveland, Ohio, and an engineer by profession. The Advisory Committee, like the School of Aviation Medicine, had been a relatively small agency specializing in aeronautical research and development, composed mainly of engineers and little known except to flyers. Its relations with the Air Force had been cordial and coöperative, but limited largely to the solution of engineering problems.

NASA had no expectation of remaining either small or obscure. Well aware of the powers which the Congress had written into its charter, NASA proceeded to carry out its mandate by wielding them to the full extent which they permitted. Hardly was the President's signature dry on the National Aeronautics and Space Act, before Mr. Glennan had even arrived in Washington to assume his office, when NASA exercised its authority to take over the most ambitious program of space operations then in the early stages of design studies within the military services. It was the "Man in Space" project of the Air Research and Development Command, to launch a manned satellite into orbit. Rechristened Project Mercury, it became NASA's bid to overtake the Soviet lead in space exploration.

The project was announced early in January 1959. To evaluate the qualifications of the candidates for selection as the first seven astronauts (three from the Air Force, three from the Navy,

and one a Marine), NASA had chosen the only civilan medical agency with the knowledge and experience to administer the tests: the Lovelace Foundation in Albuquerque, New Mexico. The tests and the subsequent training of the candidates selected were to be given by the Aero Medical Laboratory in Dayton (known to NASA through its association with the engineering facilities of the Air Materiel Command, and later of the Air Research and Development Command, at Wright-Patterson Air Force Base) and by various research laboratories of the Navy in the vicinity of Washington, Cleveland, and Langley Air Force Base, Virginia, where the Advisory Committee for Aeronautics had been headquartered and where the Mercury flight program was to be based.

A contract for the development of the space craft was awarded to the McDonnell Aircraft Corporation in St. Louis. McDonnell was to be responsible for the design of its life-support systems under NASA supervision, and would sub-contract the fabrication of the hardware itself to other companies specializing in equipment of this kind. Thus the School of Aviation Medicine, for all its background in the medical aspects of space flight and the notoriety given to it by the Farrell experiment, was excluded from any part in NASA's plans for Project Mercury.

The change of climate in the American space effort was evident just before the close of 1958, when the School sponsored its second International Symposium on the Physics and Medicine of the Upper Atmosphere and Space.[6] Again the site was the former Plaza Hotel (now the San Antonio Hilton). Once more the speakers included many illustrious names in the biological and physical sciences both in the United States and abroad.

This time the arrangements were made for the School by a scientific organization near at hand: the Southwest Research Institute of San Antonio, founded a few years earlier by Tom Slick Jr., a second-generation petroleum peer and financier, with his family. The guest of honor was the Senate Majority Leader, Lyndon B. Johnson, making his second appearance of the year at an event of national interest sponsored by the School. The usual battery of news reporters and television commentators was on hand as before.

In spite of these advantages, the second Symposium was something of an anticlimax compared with the first. In 1951, a serious

scientific meeting devoted to the problems of space flight had been a novelty, and the problems themselves had been new and intriguing. The School at Randolph had been the only institution conducting practical and systematic experiments in this field. Since then, many other scientific societies had scheduled discussions of the same problems at their annual meetings, and other institutions around the country had embarked on similar studies, including the Southwest Research Institute itself.

Moreover, the National Aeronautics and Space Administration, with its headquarters at the fountainhead of information and authority in Washington, now was the official spokesman on American space programs. The School at Randolph was relieved of its sometimes embarrassing role for the past decade as the one oracle known and accessible to the press on the subject of progress by the United States toward the realization of manned space flight.

At the moment, the School was very little concerned with the founding and growth of NASA, except as an interested spectator. Aften ten years of uncertainty and suspense, the School was getting ready for its transfer from Randolph to the new quarters provided for it by the Congress at Brooks Air Force Base.[7]

The five buildings which were nearing completion at Brooks comprised the first of three groups which were to be erected in the next few years. Put up at a cost of only $9,750,000, they represented much less in the way of working space and equipment than the School now needed, but a great deal more than it now had at Randolph. By the time the project was finished, the estimated cost would reach $28,450,000—almost the amount asked for ten years earlier by General Armstrong—but after much of the original complex had been eliminated.

The buildings, of chaste brick in simple functional designs, stood on a knoll at the northwest corner of the base, more than a mile away from the aggregation of antique structures where the School had made its home thirty years before. The largest stood four stories tall above a basement, and was known as the Research Institute. It had been planned solely for the use of laboratories. But much of its space had now been preempted to house the offices of the commander, with the key members of his staff, and the 47,000-volume Aeromedical Library.

The Academic Building, in which the teaching functions were to be brought together, provided sixteen modern class rooms seating as many as 735 students, an assembly hall seating 433 more, offices, a book store and coffee shop, and examining rooms. Along with the other buildings, it was served by a closed-circuit television system for laboratory demonstrations, lectures of general interest, news events, and other educational programs.

The Altitude Laboratory was to house the pressure chambers, eventually a large human centrifuge, and other heavy pieces of experimental apparatus, as well as the offices and laboratories of the Department of Physiology. A smaller Flight Medicine Laboratory would shelter the clinical consultation and examining rooms and offices.

The Research Shops, photographic laboratory, television studios, and similar services allied with research and teaching were to be contained in another building behind the Research Institute. All of these buildings were to be climatized at appropriate temperatures for the work under way in them from a central heating and cooling plant.

Even with these vastly enlarged facilities, the administrative support functions of the School—and some of its staff offices and laboratories—would necessarily spill over into 36 of the antiquated buildings and hangars on the old part of the base. In default of family housing, those officers and married airmen who did not own or rent homes in San Antonio—including General Benson—would continue to occupy their quarters at Randolph and would drive the eighteen miles or so to Brooks every day.

Despite these drawbacks, the situation at the new site was an improvement over the scattered collection of random facilities at Randolph—mainly because the base would belong to the School, and could be developed to fit the School's needs in the years ahead.

Like any private householder, the School had amassed an enormous store of equipment, possessions, records, and keepsakes of historical interest over its years at Randolph. During July 1959, they were crated and labeled and carted over to Brooks on lines of trucks, to be installed wherever room could be found for them at the new headquarters. By August, the move was virtually

complete, and General Benson transferred his command post to Brooks. The first group of medical officers to attend classes in the Academic Building assembled there a week later.

Because of the limited facilities for housing and recreation, the branch School at Gunter Air Force Base, Alabama, could not be returned to San Antonio at the same time. The Flight Nurse Course and several others directly associated with the practice of aviation medicine were transferred to Brooks. The rest remained at Gunter for the time being, in what was now called the Medical Service School.

The primary deficiency in the new installation, so far as the purpose for which it had been built was concerned, was of course the lack of a clinical facility for the treatment of flyers with specialized medical problems, in conjunction with the research and instruction carried on by the School It was the early elimination of this clinic which had led the Air Force to abandon its original conception of the organization at Brooks as an Aeromedical Center.

But General Benson was a man of strong convictions and inflexible purpose in his view of the professional services which the School ought to provide for the Air Force. He had never fully given up the idea that what was now arising at Brooks was to be in fact the Aeromedical Center of the Air Force as General Armstrong had conceived it.

Beginning in January 1959, a few months before the quarters at Brooks were to be occupied, General Benson had applied the same energy and enthusiasm to the search for a means of realizing the Center that he had given to the campaign for the recognition of aviation medicine as a specialty a few years earlier. In a series of conferences with Air Force authorities in Washington and at Randolph, he had put forward an alternate proposal.

The Air Training Command had never been entirely happy with the removal of the School from its jurisdiction to that of the Air University after World War II. The Training Command too had seen the era of space flight approaching, and had wanted to have a part in it. Through the School of Aviation Medicine, it would have had a hand in the training of astronauts and of the flight surgeons and others who would attend them.

At Lackland Air Force Base, a mere ten miles or so from Brooks and a major center of the Training Command for the basic instruction of recruits. the Air Force then was building the first 500-bed wing of a planned 1,000-bed hospital which was to be the largest and most modern clinical institution of the new Air Force Medical Service. Costing $14,000,000, it was to serve not only as a general hospital for Air Force personnel and their dependents in the San Antonio area, but would be also a center for referral of cases requiring specialized treatment from other Air Force stations around the world.

The institution at Lackland would be a teaching hospital, offering internships to young physicians whose medical education had been sponsored by the Air Force and residencies in a dozen or more major medical specialties. Besides, it would conduct research on new clinical techniques for diagnosis and treatment. In short, the new Lackland Hospital was exactly the kind of therapeutic center which the School had intended to include in the complex at Brooks, though considerably larger than the modest clinic that General Armstrong had envisioned.

In effect, then, General Benson had offered the Air Training Command a deal. If the Lackland Hospital could be reassigned to the School of Aviation Medicine as the missing element of the Aeromedical Center, he would use all his arts of persuasion to induce Air Force Headquarters to transfer command jurisdiction over the School and the Center from Air University back to the Training Command. This rather visionary proposal had been accepted by the Air Training Command and approved by Air Force Headquarters.

So on August 20, 1959, just two weeks after General Benson moved his headquarters to Brooks, orders were issued in Washington establishing the Aerospace Medical Center as a unit of the Air Training Command, to take effect on or about October 8. Besides the School of Aviation Medicine and the Hospital at Lackland, it was to include the Medical Service School at Gunter Air Force Base, Alabama. For good measure, it would take over the Air Force Epidemiological Laboratory—also at Lackland—as well. (The Laboratory was a physically small but geographically far-ranging unit that served the Air Force in the control of infectious diseases wherever squadrons were stationed around the world.)

The first commander of the Aerospace Medical Center was to be General Benson.

Thus, by this rather roundabout procedure, General Benson was able to complete General Armstrong's plan to create an Air Force medical center after all. It was not quite the unified institution which they had been working to achieve, with all of its complementary facilities concentrated at the same site. But it contained all the necessary elements of a center at which medical research, teaching, and clinical treatment were intimately linked together toward a common end—the discovery, testing, and dissemination of improved procedures for the care of flyers.

On November 14, 1959, Senate Majority Leader Lyndon B. Johnson journeyed to Brooks from Washington once more, with his fellow Senator from Texas, Ralph W. Yarborough, and Congressman Paul J. Kilday. There, in the presence of the Secretary of the Air Force, James H. Douglas Jr.; the Chief of Staff, General Thomas D. White; the head of the Air Training Command, Lieutenant General James E. Briggs; the Surgeon General, Major General Oliver K. Niess; and General Benson, he dedicated the Aerospace Medical Center.

Both Senator Johnson and Representative Kilday, in their addresses, emphasized that the final realization of the Center was as much a triumph for the Congress—which viewed it as a national medical institution complementing the operational and engineering facilities of NASA and the military services—as it was for General Armstrong and General Benson, who had conceived it and brought it into tangible existence.

In this new organization, the School lost some of its historic independence as the sole and supreme authority on aerospace medicine in all its varied aspects. But the School retained its separate identity as one of the two major components of the Center. Moreover, while the Aerospace Medical Center now was the overall command echelon of the combined units, its name and function existed largely on paper. The School of Aviation Medicine still was the organization that carried on the work of the Center in research and education. General Benson, for the time being, was the commander of both.

It was unlikely that the School would lose its identity altogether. For years to come, in places far removed from San Antonio, if the Aerospace Medical Center (or one of its successor agencies) was mentioned, even Air Force officers were likely to look blank and ask: "What's that?" But if the School of Aviation Medicine was mentioned among flyers anywhere, they knew exactly what it was and where it was located. In their knowledge lay the value of a name with almost half a century of tradition behind it.

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Chapter 17

THE CENTER

The effects of NASA's founding on the School of Aviation Medicine and the Aerospace Medical Center in the early months of its existence were multiple and complex. Some of them would only become noticeable later. The removal of the School from the public eye as a symbol of space research and development, to be replaced by NASA, was only one of the least of these effects, and one which was not entirely unwelcome to the staff.

In the spring and summer of 1959, when the Center was being organized, the Air Force had felt some concern that NASA might decide to annex the School, with its new and more commodious laboratories at Brooks, as it was presently to annex the missile development facilities of Doctor Von Braun at Huntsville, Alabama, from the Army.[1]

That such a proposal by NASA would succeed was unlikely. The Air Force obviously could not perform its duty to defend the nation against an air attack without a large and competent medical service. The School of Aviation Medicine was its only source of medical specialists, flight nurses, and technicians, trained specifically to maintain the health and effectiveness of flyers. Air Force Headquarters could be expected to raise strenuous objections to the loss of its sole institution for the development of skilled medical personnel and techniques, and the Administration could hardly fail to appreciate the soundness of its objections.

Nevertheless, this possibility had been one of the reasons for the organization of the Aerospace Medical Center within the Air Training Command. Air Force authorities had felt that the School would be better able to resist a movement to absorb it into NASA's burgeoning chain of technical facilities across the country if it had the protection of a larger and more powerful command, directly

responsible for the air arm's fighting efficiency, rather than that of a more or less detached and intellectual agency such as the Air University.

Now that the change was accomplished, and the Aerospace Medical Center was established at Brooks with the overt approval of the same Congressional leaders who had established NASA, the School waited confidently for NASA's leaders to approach the Center for assistance in their most ambitious project to orbit an American astronaut in space at the earliest possible date.

In the view of the School, NASA had now been added to the list of governmental and private agencies—including the Federal Aviation Agency, the airlines, aerospace industry, and some fifty nations overseas, as well as the Army, the Navy, and the Air Force—that were concerned with human flight and had at one time or another required support from the School's research, teaching, or clinical staff in the conduct of their development or flight operations.

But an astonishing silence followed instead. By the end of 1959, when the Aerospace Medical Center was ready for business, it had become apparent that the engineering brains in charge of NASA either were unaware of the School and its capabilities or were determined to ignore the School because of its long association with the military services, and were bent on developing a civilian counterpart of their own.

In research, NASA was beginning to acquire its own laboratories across the country and to seek out universities and private research agencies, offering them munificent contracts to investigate problems which the School had studied for the past decade or longer, and to determine the validity of data and conclusions which the School already had presented openly at scientific meetings, in papers published by professional societies, and in its own widely distributed project reports.

In developing an organization to conduct the flight operations at which Project Mercury aimed, an even more astonishing situation was becoming evident. Either NASA had not realized or so far it had ignored the fact that—like the Air Force, the Army, and the Navy, and perhaps more than any of them, in view of the

exotic medium in which NASA's operations were to be conducted—it would have need of an extensive medical service, complete with flight surgeons, clinical assistants, and treatment facilities, to sustain the health of its astronauts, to oversee the design and effectiveness of the life-support systems provided for them in the Mercury space craft, and to monitor their condition from the ground during flights.

Up to now, there was little indication that NASA had even thought seriously about this eventual need. For advice on the selection and training of its first seven astronauts, NASA had drawn on the services of Brigadier General Don Flickinger, Surgeon of the Air Research and Development Command. For routine medical examinations and treatment of minor ailments, NASA had sent the astronauts and their dependents to the Tactical Air Command Hospital at Langley Air Force Base, Virginia. It was the nearest clinical facility to the Langley Research Center that NASA had inherited from the National Advisory Committee for Aeronautics, where the astronauts now were nominally stationed.

Their personal physician was Lieutenant Colonel Stanley C. White, a flight surgeon borrowed from the Air Force, with two young medical officers as assistants: Army Captain William S. Augerson and Navy Lieutenant Robert B. Voas. Doctor White traveled with the astronauts. Also he advised both NASA and the McDonnell Aircraft Corporation on the design of the life-support systems to be built into the space craft. This was the extent of the medical care provided by NASA for its astronauts in the autumn of 1959, when the Mercury program was almost a year old and the Aerospace Medical Center was activated.

Another six months would pass before NASA got around to appointing a medical director for its flight programs at the headquarters of the agency in Washington. Then the appointment would go to Dr. Clark T. Randt, not a flight surgeon or a specialist in aviation medicine, but an esteemed neurosurgeon from Cleveland, Ohio, and a family friend of the Administrator, Mr. Glennan.

The organization of NASA was of course no concern of the Aerospace Medical Center or of the School. But from its many years of service to flying organizations and to flyers, the School was well aware that the adequacy of the medical support provided

for the astronauts would have a profound effect on the success of Project Mercury. The object of the program was to reduce the Soviet lead in manned space operations. Sooner or later, if that object was to be achieved, the medical support provided thus far would have to be vastly augmented.

The only available source of medical advice and assistance on the scale needed by NASA was the Aerospace Medical Center at Brooks. It had been the intention of the Congress that the Center should provide this help to NASA as well as to the flying units of the Air Force. The Center and the School were now ready to provide it. The success of Project Mercury was an end devoutly to be wished by most Americans, military or civilian. Every month's delay in achieving a relationship of mutual understanding between NASA and the Aerospace Medical Center might retard the success of the program by that much.

Through 1960 and the first months of 1961, the Center was asked by NASA to perform just three relatively minor research tasks. Even before the Center was organized, in the spring of 1959, NASA had asked the Department of Space Medicine at the School—now under the direction of Dr. Hans-Georg Clamann after the reassignment of Colonel Steinkamp—to prepare a small life-support capsule for a Rhesus monkey, to be lofted in a Little Joe research rocket to a moderate altitude, ejected in flight, and later recovered.[2] The purpose of the flight was to test the escape system developed by NASA for the Mercury astronauts if the space craft should fail in the early stages of its launching. Secondarily, the aim was to evaluate the Mercury life-support systems and monitoring techniques themselves.

Doctor Clamann and his aides (one of them was Lieutenant Colonel David G. Simons, who had launched the first animals to be recovered from a rocket flight at Holloman Air Force Base eight years before) had designed and built the capsule, with its instruments to record the primate's reactions to the stresses it would undergo during the test, and had trained the monkey to perform certain simple tasks in flight as an indication of the effects of these stresses on the astronaut's performance.

On December 4, 1959, the capsule had been launched from NASA's Wallops Island Test Center on the Eastern Shore of

FIGURE 21 —

Physical examinations under varying conditions of stress are part of the medical evaluation of astronauts.

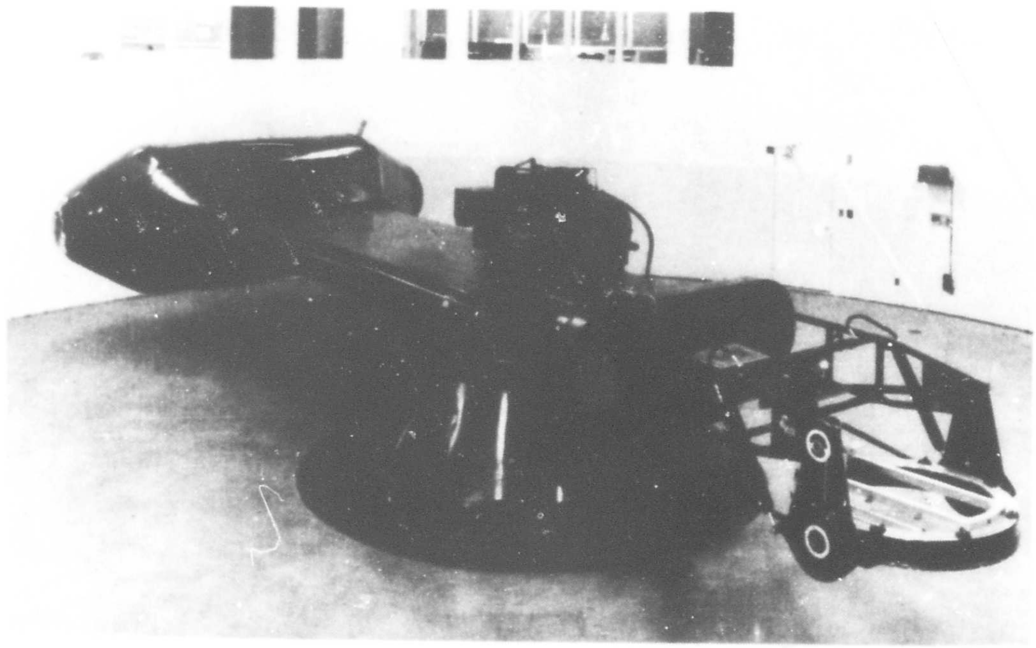

FIGURE 22 —

This centrifuge at the School is used as a research tool, a teaching instrument, and in the medical evaluation program. A subject can be instrumented, placed in the centrifuge and exposed to G-forces experienced in lift-off or re-entry of a space probe.

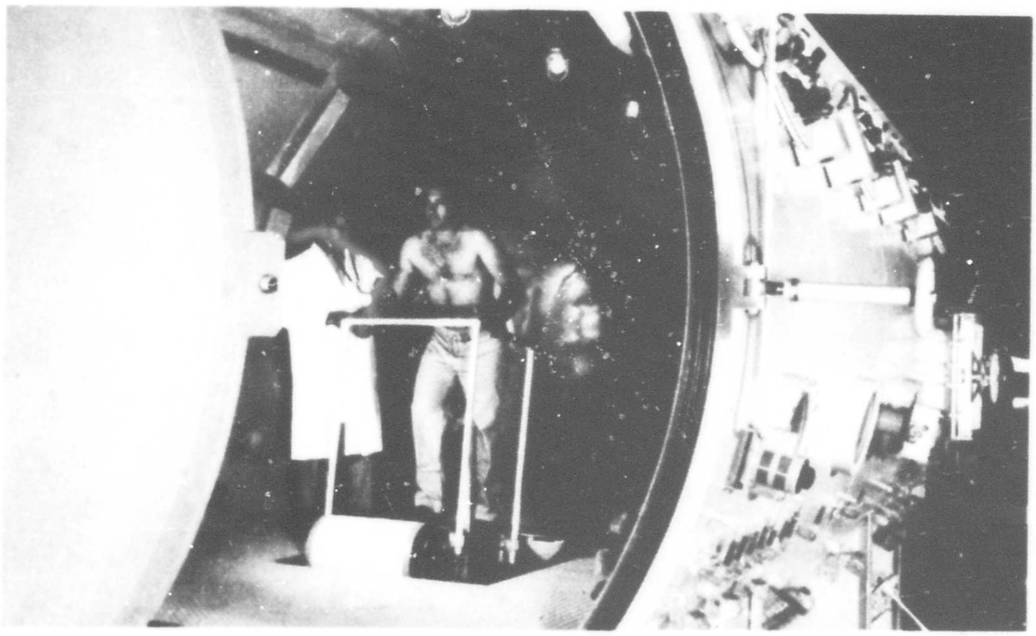

FIGURE 23 —

This space cabin simulator at the School is fully equipped to continuously support four men up to 30 days at selected barometric pressures in varied atmospheres.

Virginia, not far from Langley Air Force Base. Just before the rocket's burnout, the escape capsule had been ejected by its own rocket booster system, climbing to an altitude just under 53 miles. The monkey—still in its capsule—had been recovered from the ocean by a Navy destroyer six hours later. It had survived unharmed and had provided the data needed on the severity of the stresses which it had undergone.

The test had been repeated in January with another Rhesus monkey in a similar capsule atop a second Little Joe rocket. Again the experiment was a success. One result of the tests was to gain the confidence of NASA engineers and scientists at the operating level in the personal competence of Doctor Clamann. Appointed a member of NASA's Advisory Committee on Biotechnology and Human Research, he had served as a point of diplomatic contact between NASA's operational programs, on the one hand, and the research capability of the School and the Center, on the other.

The second research project in which the School was a participant with NASA was a series of high-altitude balloon flights, with mice and samples of living tissue as the subjects, carried out over Bemidji, Minnesota, in July and August 1960. This time the monitor was Doctor Simons, who had himself made the same kind of flight only three years earlier.[3] The object was again to determine the possible effects of prolonged exposure to cosmic radiation in the upper levels of the atmosphere and beyond.

The balloons, with their animal subjects in life-support capsules resembling in miniature the one which had sustained Doctor Simons, reached altitudes as high as 27.5 miles, some 8.5 miles above the most remote point attained by Doctor Simons himself. Again the results were almost entirely negative, showing that astronauts had little to fear from exposure to cosmic particles over periods of several days in orbit.

Finally, the School received from NASA a contract to investigate the effects on the astronauts of a cabin atmosphere consisting almost entirely of oxygen, for space flights lasting two weeks or longer.[4] The reason for this inquiry was the same one that had led the Department of Space Medicine, in its first experiments with space-cabin environments, to choose an atmosphere having only half the pressure at sea level but with twice the

proportion of oxygen. The weight of a system at sea-level pressure was prohibitive in view of the limited thrust of the Atlas booster; but the astronauts could not survive on less than the amount of oxygen available in the air close to sea level.

NASA's contractor for the Mercury space craft, McDonnell Aircraft Corporation, had decided that even the weight of a system pressurized at half an atmosphere was prohibitive. Instead, McDonnell had recommended a cabin environment providing only one-third the pressure at sea level (roughly 258 mm Hg), equivalent to an altitude about 5 miles above the Earth, but with oxygen as its sole component in a ratio more than 1.5 times the proportion available at sea level.

The question was what effect this high concentration of oxygen would have on the crew in space flights lasting more than a few hours. The answer would affect NASA's plans for later programs, after the Mercury series was completed.

Doctor Clamann had lately received a new space cabin, larger and more sophisticated than the one in which the Farrell experiment had been conducted, with room for two men and a greater variety of more exact instrumentation. The project monitor was Billy E. Welch, Ph.D., head of the new Space Ecology Branch of the Department.

In this cabin, on February 10, 1961, two young Air Force officers completed a simulated flight of 17 days, under conditions closely approximating those of an actual sortie into space, breathing an atmosphere composed of 98 per cent oxygen plus a small amount of carbon dioxide and varying proportions of water vapor. Both pilots, they were Captain William D. Habluetzel, who also held a bachelor's degree in biology, and Captain John J. Hargreaves. Actually, the environment was even more rigorous than the one which NASA had specified, consisting of a pressure equivalent to 6.3 miles. But neither subject had suffered ill effects of any consequence from the experiment.

While Captains Habluetzel and Hargreaves were still orbiting in their Earth-bound space craft, momentous changes had been taking place in the Center at Brooks. Early in October 1960, the authoritative *Army-Navy-Air Force Jounal,* published in Wash-

ington, had carried an announcement that General Benson would retire soon after the close of the year, and that his successor would be Brigadier General Theodore C. Bedwell Jr., then Surgeon of the Strategic Air Command.[5]

General Benson now had commanded the School and the Center for four years of his present tour, and for eight years altogether. He had completed the tasks for which he had been assigned there, transferring the School to Brooks and overseeing the organization of the Center. Under normal Air Force procedures, he was due for a change of station and the institution at Brooks was ready for a change of command.

As a fully recovered heart patient, General Benson at 58 was as youthful, incisive, and energetic as ever. But the few Air Force assignments which were available for a medical officer of his rank and distinction—limited mainly to the Surgeon General's office, the United States Air Forces in Europe, and now the Aerospace Medical Center itself—were considered overly strenuous for a person with his medical history. So it had been decided to place him on the retired list a year or two prematurely, and to appoint a younger officer as his replacement.

Meanwhile in August, General Benson had given up his dual role as commander of both the School and the Center. To command the School, he had appointed his Deputy, Colonel Robert H. Blount, a native Texan (the first, in fact, to hold that position in the forty-five years that the School had been a Texas institution) and a former medical air attaché in Paris. So the change in command was only for the Center. Colonel Blount would continue as commander of the School.

In the first week of January 1961, General Bedwell had arrived at Brooks to familiarize himself with his new command before he accepted it formally from General Benson. On January 18, orders had been published officially in Washington, placing General Benson on the sick list in the Center's own Air Force Hospital at Lackland for routine medical examinations on the eve of his retirement, and designating General Bedwell as his successor.

For the next two weeks, General Benson had escorted General Bedwell around the base, introducing him to key members of the

staff and explaining the details of their work, which were by some uncanny mental process invariably as well known to him as they were to the staff itself. On February 1, at 10 o'clock in the morning, in a brief and simple ceremony on the old flight line at Brooks, General Benson reluctantly gave up the command which he had created largely by his own ingenuity and persistence, handing it on to General Bedwell.

Thus ended the era in aerospace medicine which had lasted a quarter of a century or longer under the leadership of General Grow, General Armstrong, and General Benson.

For the next few months, before his formal retirement, General Benson was nominally assigned to the Hospital at Lackland as an ambulatory patient. From time to time—like every old employe in the early days of his retirement—he would drop in at Brooks to talk with old cronies like Colonel Blount and Colonel Paul Campbell, who had returned from Europe a year or two earlier to become the senior member of an advisory planning board for future research, the Advanced Studies Group. (Other members of this Group were Doctor Strughold and Colonel John Paul Stapp, reassigned to the Center a few months before after commanding the Aero Medical Laboratory in Ohio.) Colonel Campbell was to succeed Colonel Blount as commander of the school in 1962, on the eve of his retirement.

Relieved of his patient status at the Hospital in June with a clean bill of health, and placed formally on the retired list, General Benson vacated his quarters at Randolph and moved into a handsome home in San Antonio. Still active, and with more energy than he could consume in social functions, he formed several alliances as a consultant to aircraft companies in the field of aerospace medicine.

A year or so later, when these random services turned out to be less than enough to keep him busy, Doctor Benson took on another full-time job as a civilian. He was appointed Director of Aerospace Medicine at the Southwest Research Institute, the growing organization which had managed the arrangements for the second International Space Symposium sponsored by the School in 1958. There, on the eve of aerospace medicine's fiftieth anniversary in 1967, General Benson persuaded his old friend and patron,

General Armstrong (then living in Maryland since his own retirement ten years before), to join him.

Together, then, these last surviving architects of the modern specialty of aerospace medicine were to pursue their common interests, and to watch with critical eyes the progress of the institution which they had shaped, as it advanced through the nineteen-sixties.

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Chapter 18

THE DIVISION

General Bedwell differed as much from his immediate predecessors in command of the institution at Brooks as they had differed from one another.[1] To begin with, he was—like Colonel Blount—a native Texan, from the town of Caddo Mills, some forty-five miles northeast of Dallas. But he was not the bland, free-wheeling sort of prestidigitator that this background conjured up in the minds of many non-Texans. On the contrary, General Bedwell was quiet-spoken, thoughtful, considerate of his associates, and exceedingly competent in his profession.

In civilian clothes, wearing the customary cattleman's boots of the region, General Bedwell might have been taken for a circuit judge or a prosperous business man in a small Texas community. Actually, of course, he was an accomplished physician with a leaning toward clinical practice, a flight surgeon, an accredited specialist in preventive medicine and occupational medicine as well as aviation medicine, and an able administrator of long experience in command positions.

As with every commander since World War II, he had been selected by Air Force Headquarters not only for his known ability to handle the organization which he inherited from General Benson, but also to represent—and to assist in putting into effect—a new policy on which he had been thoroughly briefed before he left Washington. That policy was to guide the Aerospace Medical Center, with as little disturbance as possible to its staff and its programs, while it was being transformed into a still larger and more authoritative organization, better able to deal with the changed conditions brought about by the founding of NASA and its precipitate growth into a branch of the Government rivaling the Department of Defense in its power and its resources.

The idea of expanding the Center's authority to make its position more secure antedated General Bedwell's appointment by more than a year. As early as September 15, 1959, two weeks before the Center had been organized and transferred to the Air Training Command, Lieutenant General Bernard A. Schriever, head of the vast Air Research and Development Command which had overseen the evolution of the American ballistic missile capability for defense and retaliation against an assault with nuclear weapons, had put forward this proposal in a letter addressed to Air Force Headquarters.

At that time, the Senate Majority Leader's own Committee on Aeronautical and Space Sciences—which had been largely responsible for the creation of both NASA and the Aerospace Medical Center—had just completed an exhaustive investigation of NASA's research programs in the life sciences during the first year of its existence. Although the Committee had reserved judgement on NASA's management of these programs, the implication in the report was clear that NASA was encouraging a considerable amount of wasteful duplication among the agencies in this field, instead of making the fullest possible use of the Aerospace Medical Center, whose enlarged facilities at Brooks Air Force Base had been provided by the Congress for this specific purpose. The Air Research and Development Command also had been cited on the same grounds.

In his letter, General Schriever had pointed out the need to eliminate costly duplication of research in aerospace medicine and the biological sciences. He had quoted "repeated recommendations" by the Scientific Advisory Board of the Air Force that research in the life sciences by the School of Aviation Medicine and by the various laboratories of his command should be combined in a single agency. Also he quoted a request from the Congress that the Department of Defense make a thorough study of the question and report on its findings by the middle of January 1960.

As a solution to these problems, General Schriever had suggested that the Aerospace Medical Center should be incorporated into his command and consolidated with the other life-science laboratories already under the management of Air Research and Development Command Headquarters.

At the moment when General Schriever's letter had arrived, plans had already been completed, and orders written, for the creation of the Aerospace Medical Center within the Air Training Command. It had then been too late to countermand these plans, and to replace them with an alternate arrangement to put the School of Aviation Medicine under the Air Research and Development Command. But the Surgeon General and the Air Staff had been impressed by General Schriever's arguments, and had been considering them with increasing favor ever since.

The author of General Schriever's proposal had been his Assistant for Bioastronautics and Surgeon of the Air Research and Development Command, Brigadier General Don Flickinger. The strongest opponent of the plan had been General Benson, who had looked on the Aerospace Medical Center as a strictly professional organization—one which would suffer, and not gain, by incorporation into the engineering and scientific facilities of the Air Research and Development Command. General Benson's belief had been heartily seconded by Lieutenant General James E. Briggs and Major General M. S. White, then the commander and surgeon respectively of the Air Training Command.

But the plan had endured, gathering momentum as the growth of NASA and the proliferation of its life-science programs had continued. By the autumn of 1960, the Air Staff had been persuaded to adopt it. The decision had coincided with the approaching end of General Benson's tour as commander of the Center. So the Surgeon General's office had looked about for a successor to General Benson who would be equally familiar with the plan and sympathetic to its aims.

The successor chosen was General Bedwell. A year or so earlier, he had served on a three-man committee of senior medical officers to consider ways of providing for closer coördination among the air commands involved in the conduct and use of programs in aerospace medical research. His fellow members on the committee had been Major General Aubrey L. Jennings, in the office of the Surgeon General, and Brigadier General Benjamin A. Strickland Jr., former commander of the School of Aviation Medicine's branch—now the Medical Service School—at Gunter Air Force Base, Alabama. General Strickland, incidentally, was to become the Surgeon of what had been the Air Research and

Development Command when General Flickinger was retired for medical disability in August 1961.

In the autumn of 1960, furthermore, another change had occurred in Washington. A new national administration had been elected, led by former Senator John Fitzgerald Kennedy as President and by former Senator Lyndon B. Johnson as Vice President. Because of the Vice President's past interest in space activities, it was generally assumed that the Kennedy Administration would give more attention to space programs—both military and civilian—than they had enjoyed under President Eisenhower. This belief seemed to have been confirmed when President Kennedy appointed Mr. Johnson to represent him as Chairman of the National Space Council, with authority over NASA and the other agencies participating in the American space effort.

Rumors of the impending change in the command affiliation of the Center had preceded General Bedwell when he arrived at Brooks early in January 1961. Twelve days after the new Administration took office on January 20, General Bedwell assumed command of the Center and General Benson departed, on his way into retirement. Two weeks later, Vice President Johnson visited Brooks with a retinue of staff assistants and press correspondents, flying over from his ranch near Johnson City.

The Vice President was only one of a stream of visitors at Brooks over the next several months. They included Major General Oliver K. Niess, the Surgeon General; Colonel Jack Bollerud (a former assistant to General Flickinger) from Air Force Headquarters; Representative Emilio Q. Daddario, chairman of the House Committee on Science and Astronautics; Dr. Edward C. Welsh, newly appointed Executive Secretary of the National Aeronautics and Space Council; and eventually General Schriever himself, to examine the facilities which he was about to acquire.

But no official announcement was to be made of the approaching transfer to another air command until the plans were completed and the orders were issued.

Meanwhile, after testing the life-support systems in the Mercury space craft on a suborbital flight down the Atlantic Missile Range at the end of January 1961, with a trained chimpanzee from

the Laboratory at Holloman Air Force Base in the pilot's seat, NASA prepared to send its first human astronaut aloft on a similar test in May.

Once again, however, Soviet technology beat its American counterpart to the draw. On April 12, 1961, from the same missile test site in Asia that had sent Sputniks 1 and 2 into orbit, a young major in the Soviet Air Force, Yuri Alekseyevich Gagarin, became the first human being launched on an orbital flight in space. An hour and forty-eight minutes later, after circling the Earth once, he landed safely with his craft at a point near the Volga River, somewhere southeast of Moscow. The space craft, weighing 4.7 tons with its passenger, its life-support systems, and its guidance and communication mechanisms, was called Vostok 1. The cabin was roomy enough to allow the cosmonaut some freedom of movement during the flight, and it was strong enough structurally to provide a normal atmosphere under the full pressure of the Earth's air at sea level.

After this performance, as after the first Sputniks, three and a half years earlier, the inaugural flight of the Mercury space craft on May 5 was almost an anticlimax, even though it was carried out in full view of the public on television. Powered by an Army Redstone booster, rather than by the Atlas which would eventually lift it into orbit, it took Navy Commander Alan B. Shepard to a height of 116.5 miles above the Atlantic Missile Range, and lowered him to a safe landing and recovery in the South Atlantic Ocean.[2]

The Shepard flight was repeated on July 21, successfully again, by Air Force Captain Virgil I. Grissom. But the Soviet Union, three weeks later, launched its second orbital flight by Soviet Major Gherman S. Titov. This time the Vostok space craft was aloft for 25 hours and 18 minutes, completing 17.5 circuits around the Earth before it landed, safely as before, in the same area where Gagarin had come down. The American space-flight program still was well behind the Soviet schedule—perhaps farther behind than it had been in 1957, despite NASA's mighty efforts to catch up.

Early in October, Air Force Headquarters finally announced that the Aerospace Medical Center, after only two years of existence under the Air Training Command, was to be absorbed into

General Schriever's Air Force Systems Command (the new name of what had been the Air Research and Development Command, now considerably expanded) as the Aerospace Medical Division, comparable to the other specialized divisions of the Systems Command scattered across the country from Boston, Massachusetts, to Inglewood, California.[8] The reorganization was to take effect on November 1, and was to be completed by the end of the year.

Besides the School of Aerospace Medicine (also lately renamed) and its other units at Brooks, where it would have its headquarters, the new Division was to bring with it the Air Force Hospital at Lackland and the Epidemiological Laboratory, likewise at Lackland. The Medical Service School in Alabama (now producing mainly clinical technicians and dental and administrative officers and assistants) would stay with the Air Training Command.

To these subordinate elements were to be added the Aerospace Medical Research Laboratories that General Armstrong had founded a quarter of a century ago at Wright-Patterson Air Force Base, Ohio (now also the site of the Aeronautical Systems Division of the Systems Command); the Aeromedical Research Laboratory which it had later established at Holloman Air Force Base, New Mexico (now also the site of the Missile Development Center of the Systems Command); the Personnel Research Laboratory which the School had helped to found at Lackland Air Force Base in World War II, now another unit of the Systems Command, though its studies were performed mainly for the use of the Deputy Chief of Staff for Personnel at Air Force Headquarters; and the Arctic Aeromedical Laboratory of the Alaskan Air Command (another post-war offshoot from the School) near Fairbanks, Alaska.

Thus the Aerospace Medical Division, greatly enlarged, with subordinate research laboratories reaching from its headquarters in Texas to the Arctic, would command virtually all of the Air Force facilities for aerospace medical research, development, and testing, for postgraduate training of medical officers, nurses, and technicians in aviation medicine and its related specialties, and for clinical diagnosis and treatment of flyers afflicted with disorders in these areas of medicine. Though not exactly the professional institution that General Armstrong and General Benson had planned, it would be very much more comprehensive in its resources and its authority. Besides, it was to relieve Systems

Command Headquarters (which consisted mainly of specialists in the physical sciences and engineering) of the task of managing and monitoring the conduct of research and development programs in aerospace medicine by other military and civilian laboratories working for the Air Force.

In short, the Aerospace Medical Division would assume the unique position of surveillance over its field of interest that the original Medical Research Laboratory of the Army Signal Corps had established and maintained during World War I, but in the much more complex scientific community which had arisen since World War II.

The two prime purposes of the reorganization were, first, to satisfy its Congressional critics that the Air Force had consolidated all of its facilities for research and development in aerospace medicine into an economical and efficient unit for the management of these programs; and secondly to strengthen the new division as a national center for studies in the human areas of the aeronautical and space sciences, available to any other agency with a need for its services. The policy of the Division would be to emphasize its readiness to coöperate with other agencies, rather than to compete with them.

This, then, was the program laid out for General Bedwell to apply and follow as the first commander of the Aerospace Medical Division. His task was not to be an easy one. In January 1961, more than half a year before the organization of the Division was decided on officially, NASA had announced that it was opening a new Life Sciences Laboratory in the Ames Research Center which it had lately acquired, next door to the Navy's Moffett Field in California. It was to conduct basic research studies in space biology, one of the areas which the Department of Space Medicine at the School had pioneered. An outstanding member of its staff was Siegfried J. Gerathewohl, Ph.D., a former member of the Department and a specialist on the possible effects of weightlessness.

In September, just six weeks before the Division was formed, NASA had made an even more spectacular announcement. At Clear Lake, Texas, on the coastal plain outside of Houston, and a scant 200 miles from the headquarters of the Division at Brooks Air Force Base, NASA was planning to build a new $60,000,000

Manned Spacecraft Center for the Mercury program and its future successors. (The actual cost of the Center would eventually reach $200,000,000 or more.) As soon as the Center was completed, or before, the Space Task Group in charge of flight operations would transfer its headquarters to Houston from Langley Air Force Base, Virginia.

But the rise of the monumental Center on the outskirts of Houston would have some advantages for the Aerospace Medical Division. For one, it was to use the clinical facilities of the Division's Air Force Hospital at Lackland as the treatment center for the astronauts and their families, replacing the older and less comprehensive services of the Hospital at Langley. For another, its proximity to the Air Force institution at Brooks might be expected to ease the development of an informal working relationship between them.

The two officers in charge of medical activities at the Houston Center of NASA both were Air Force flight surgeons well known to the staff of the Division. One was Lieutenant Colonel Stanley White, whose responsibility now would be primarily for the life-support systems in the space craft. The other was Lieutenant Colonel Charles A. Berry, borrowed by NASA from the Surgeon General's office, and a former department head of the School under General Benson in the late nineteen-fifties. Doctor Berry was to head the medical staff overseeing the conduct of flight operations. In effect, he would be the Flight Surgeon at the Houston Center.

At the headquarters level of NASA in Washington, too, there had been some changes. With the departure of the Eisenhower government, the President's representative as the Administrator of NASA, Mr. Glennan, had resigned and gone back to his former post as President of Case Institute in Cleveland. As his successor, President Kennedy had appointed a corporation lawyer and one-time Under Secretary of State, the Honorable James E. Webb, recommended by Vice President Johnson on the strength of his high qualifications as an effective and tactful executive.

Shortly after Mr. Glennan, his medical director, Doctor Randt, also had left NASA and returned to his practice in Cleveland. In his place, Mr. Webb had selected another Air Force flight surgeon well known to the Division and the School, Brigadier General

Charles H. Roadman. Since the late nineteen-forties, when Doctor Roadman had been a department head at the School under General Armstrong, he had become increasingly identified with aerospace medical research programs.

From Air University Headquarters, he had gone to Argentina in 1951 as American air attaché. (A pilot and physician too, Doctor Roadman had been eligible for the post of air attaché as well as medical air attaché, normally an assistant.) After attending the Air War College in 1955, Doctor Roadman had joined the Air Staff at Headquarters in Washington as head of the Human Factors Division in the office of the Deputy Chief of Staff for Research and Development. From there, five years later, he had been called to NASA as a special assistant (in the advisory capacity that General Flickinger had first filled), then as deputy and acting director in the office of Life Science Programs, and finally as Director of Aerospace Medicine.

The position that General Roadman now held with NASA was equivalent to the post of Surgeon General in the Air Force. Thus he was uniquely situated, at the high policy level of both agencies, to work toward the same goal of mutual understanding and coöperation between them that General Bedwell was expected to foster at the operational echelon in Texas.

Meanwhile, on November 29, 1961, at Cape Canaveral, Florida, NASA had tested the Mercury space craft for the first time in an orbital flight with a passenger.[4]. Not one of the astronauts, he was a 42-pound chimpanzee, trained for his assignment by the Aerospace Medical Division's newly acquired Aeromedical Research Laboratory at Holloman Air Force Base, New Mexico. The extent of the functions planned for the astronaut by NASA, in controlling the flight of the space craft, could be judged from the fact that a primate seemingly was considered qualified to replace him in this test.

Three alternate sets of controls had been provided in the craft, one for the pilot, one for the crew of engineers and technicians on the ground, and one (known as "fly-by-wire") a mixture of both. But the flight actually was directed from the ground. The astronaut was expected to serve principally as an observer, reporting on the progress of the flight and on conditions aloft, both inside

and outside the craft, and conducting certain medical and scientific experiments in space.

Nevertheless, the flight of Holloman's chimpanzee was a success. Programmed for three orbits around the Earth, the space craft actually had covered two before technical problems in its attitude control and environmental systems caused the ground crew to suspect that the outcome of the mission might be endangered. So they brought the craft down prematurely after 3 hours and 21 minutes in space. The chimpanzee, still in the space craft, was picked up from the ocean in good spirits by a Navy destroyer a little more than an hour later.

This was the last test of the Mercury systems before an American astronaut was launched into orbit for the first time. On the morning of February 20, 1962, after many delays for technical and other reasons, NASA finally committed its space craft to an operational flight with a human pilot aboard.[5]

The astronaut was Lieutenant Colonel John H. Glenn Jr., a 40-year-old Marine Corps test pilot (and thus the oldest of the seven Mercury astronauts) whose businesslike demeanor and infectious smile reminded his fellow-countrymen of retired President Dwight D. Eisenhower.

The flight went off with such apparent ease that many of the people watching it on television wondered why NASA had hesitated to launch it for so long. For five hours (less four minutes) the space craft circled the Earth, while Colonel Glenn made the observations and performed the in-flight experiments which had been assigned to him. At the end of the prescribed three orbits, it descended into the atmosphere again and dropped its burden gently into the Atlantic Ocean off the Bahama Islands, in sight of the spot where the Navy destroyer *Noa* was waiting to recover it.

The seeming nonchalance with which the operation had gone off was to a large degree an illusion. As on the test in November, technical difficulties with the automatic attitude control, toward the end of the first orbit, had led the ground crew to consider aborting the mission. But Glenn had taken over the pilot's controls in the space craft, interposing his manual dexterity and judge-

ment to correct the error. For the rest of the flight, he had stabilized the craft by his own skill.

Again, as it was beginning its descent, a signal on the ground had indicated that the heat shield at the bottom of the craft—placed there to prevent it from being consumed by friction heating in its sudden encounter with the denser air below—was loose and might be lost if the retrorockets were jettisoned after firing, as they were supposed to be. Once more, after consultation with the ground, Glenn had used his own judgement and had left the rockets intact.

As it turned out later, the automatic signal was mistaken, and the heat shield was securely in place. But if it had in fact been loose, and the retrorockets had been jettisoned on schedule, the craft and Glenn together might have been vaporized in their first collision with the upper atmosphere.

In both of these instances, the superiority of a human pilot's reason and judgement over the inflexibility of automatic instruments had been clearly demonstrated. From this moment on, NASA would begin to place more reliance on the astronaut's own skill, and would build up its medical services increasingly to support him.

If the Aerospace Medical Division had taken little part in the planning and preparation for Project Mercury, it had a conspicuous role in the conduct of the operation itself. But its function turned out to be largely clinical in nature, rather than a product of research and development.

In charge of the medical team which had been assembled by NASA, to stand by in case of emergency during the launch, to prepare the astronaut and his understudy for the flight, and to examine him again on his return, had been Brigadier General James W. Humphreys Jr., commander of the Hospital at Lackland. For the duration of the Mercury flight program, he had been appointed the Assistant for Land-based Medical Recovery to the Director of Operations.

To Cape Canaveral with him, General Humphreys had taken a substantial part of his staff and their technical aides. The

group included Colonel Robert E. Lau, Colonel Earl W. Brannon Jr., Lieutenant Colonel Charles C. Watts Jr., Lieutenant Colonel Daniel C. Campbell Jr., Major Richard C. Wolff, and two nurses, Major Marjorie E. Beakes and Captain Rose M. Luberto.

Among the medical technicians in the party had been Staff Sergeant Richard F. Bassett, Staff Sergeant Roger D. Gerloch, Staff Sergeant Charles V. Helton, Staff Sergeant Willie A. Hines, Staff Sergeant Roger J. Kuper, and Staff Sergeant Charlton Stewart.

At Grand Turk Island in the Bahamas, waiting to examine Colonel Glenn on his return, were Lieutenant Colonel Paul W. Myers from the Hospital and Captain William B. Clark from the School of Aerospace Medicine.

Two physicians from the School—along with others from the Air Force, the Army, and the Navy—had performed a service which was new in the annals of medicine. Major Fritz M. G. Holmstrom and Major George B. Smith Jr., had been borrowed by NASA as medical monitors, assigned to two of the tracking stations in the worldwide network assembled to follow the course of the flight. Doctor Holmstrom on Canton Island, in the Pacific, and Doctor Smith at Corpus Christi, Texas, had taken continuous readings on Glenn's condition from instruments attached to the flyer's body, under his pressure suit, transmitting to the ground by radio telemetry. On the strength of these recorded data, they had made long-distance diagnoses and had advised the flight director from moment to moment whether the Marine pilot was in fit shape to continue with his mission. (Invariably, he was.)

And, finally, another flight surgeon from the School of Aerospace Medicine, Captain Robert G. McIver, had been the first physician to meet Colonel Glenn and examine him on his return from space. Assigned by NASA to the fleet of Navy vessels waiting to pick him up in the Atlantic, Doctor McIver had chanced to be aboard the destroyer *Noa*. Thus to him had fallen the task of giving the first American in orbit a post-flight medical evaluation.

The same clinical coöperation between the Aerospace Medical Division and NASA continued through the next three orbital

flights in the Mercury program, closing in May 1963 with the trip of 34.3 hours and 23 orbits by Air Force Major Leroy Gordon Cooper Jr. Even though by that time the Soviet Union also had run its string of manned orbital flights to four, including one of 94.4 hours and 64 orbits, with a near-rendezvous in space between Vostoks 3 and 4, and thus had extended its lead over the United States to thirty months or longer, the operational phase of Project Mercury had been conducted with precision and dispatch, and with consideration bordering on anxiety for the safety of the astronauts, in full view of the world's television audiences, and without any fatalities or disasters.

So NASA now was established in the public's mind as a capable and responsible agency, replacing the image of failure and inadequacy which the military space programs had presented five years earlier. But the Air Force, without much public recognition for its assistance, had contributed greatly to NASA's success, most particularly in the services provided by the Aerospace Medical Division for the health and safety of the astronauts. Hence, this aspect of General Bedwell's mission as its commander also had been a success.

In several other ways, the Division had earned NASA's appreciation and good will. In the spring of 1962, NASA's Space Task Group had consulted Lawrence E. Lamb, M.D., head of the Clinical Sciences Division at the School of Aerospace Medicine and an internationally known cardiologist (he was one of the physicians who had attended Vice President Johnson—then the Senate Majority Leader—after his massive heart attack some years before, and had watched over his recovery), about puzzling heart condition discovered in one of the astronauts, Major Donald K. Slayton.

Although Doctor Lamb's recommendation had been reversed later by a board of military and civilian specialists in Washington, convened at NASA's request to consider the case, it had accorded with the opinion of the astronaut's own physicians, who had advised the Space Task Group. Thus, Doctor Lamb had come to enjoy the confidence of NASA's flight directors at the operating level in Houston. Like Doctor Clamann, he had made good use of their respect to demonstrate the advanced facilities for clinical examinations of flyers which he had developed at the School.

In the summer of 1962, more or less on a trial basis, NASA had sent its second group of candidates for selection as potential

astronauts to Brooks, for medical evaluation by Doctor Lamb and his associates, rather than to the Lovelace Clinic in Albuquerque, where the first group of seven had been examined. On the basis of Doctor Lamb's recommendations, after an exhaustive series of tests, the second panel of nine military and civilian test pilots had been added to NASA's roster of astronaut aspirants.

The outcome of this tentative association had been that the School, in the spring of 1963, had received from NASA a contract to provide medical evaluations of its future astronaut candidates. The next group was to arrive in August 1963. Many of them would be military pilots who had been examined in the past by Doctor Lamb, for entry into the test-pilot training given by the Aerospace Research Pilot School of the Systems Command at Edwards Air Force Base, California. Thus he would have their previous medical records for comparison with the current tests provided for NASA.

During the first years of General Bedwell's command, the second increment of five new professional buildings had been going up among the original five at Brooks, relieving some of the congestion in the older facilities on the base.[6] They included a long structure of two stories, looking toward the gate onto the highway, that was to serve as a headquarters for the Aerospace Medical Division, removing it from the temporary offices which it had been occupying in the crowded Research Institute of the School.

Facing the new headquarters building on one side and the Research Institute on another was the Aeromedical Library. It, too, would free space which had been occupied in the Research Institute. Beyond these buldings were the Bioastronautics Laboratory of Doctor Clamann and his colleagues, the Bionucleonics Laboratory, and a modern Vivarium for the care of laboratory animals. All would leave precious room which had been preempted in the main Research Institute.

Besides these professional structures, some family quarters and other housing additions had been completed a year or so earlier. Over on the older side of the base, on elevated ground near the East Gate, a Capehart Housing program had provided homes for 70 officers and 100 non-commissioned officers, with their families. They had made it possible for General Bedwell

and his ranking staff members and their assistants to live on the base, instead of commuting from Randolph or San Antonio. A new Bachelor Officers' Quarters had given the Division comfortable rooms for visiting dignitaries, transient officers, and senior students.

With these accretions—most of them occupied by June 1963—the complex at Brooks had begun to resemble an institution of the size and capability that General Armstrong had foreseen for it fifteen years before. Moreover, it had come to be a living community.

As the year drew toward its close, General Bedwell and his staff were making preparations for an event which was to put the final seal of recognition and approval on the professional standing of the Division and the School. A visitor of the highest rank was coming in November, to inspect the organization at Brooks and to dedicate its new facilities. Not a military leader, nor even a member of the Congress, that visiting dignitary was to be the President of the United States, John F. Kennedy. He would become the first Chief Executive of the nation ever to see its resources in person.

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Chapter 19

"CAP OVER THE WALL"

On the afternoon of November 21, 1963, John Fitzgerald Kennedy, President of the United States, touched down at the International Airport in San Antonio, Texas, after a flight from Washington, D. C.[1] With him were Mrs. Kennedy and a group of dignitaries that included Vice President Lyndon B. Johnson, Secretary of the Air Force Eugene M. Zuckert, and Governor John B. Connally of Texas.

More than a dozen members of the Texas delegation in the Congress from the President's own political party were with him also. Among these were Senator Ralph W. Yarborough and Representative Henry B. Gonzalez from San Antonio, successor to Paul J. Kilday, who had resigned to accept an appointment by Mr. Kennedy as Judge of the United States Court of Military Appeals in Washington. The President's ranking assistants and the White House press corps were in his retinue as well.

The President did not know it, but this was to be his last visit away from Washington. Its immediate purpose was to dedicate the most recent group of buildings which had been added to the School of Aerospace Medicine at Brooks. In broader perspective, the object of the trip was to reaffirm the strong support of President Kennedy and his Administration for the American program of space exploration.

With that aim in mind, the President had prepared a brief address to be presented publicly outside the headquarters of the Aerospace Medical Division, of which the School was now a major element. After the ceremony at Brooks, Mr. Kennedy had planned a quick tour of Texas that would take him to Houston, Fort Worth, and Dallas, before he flew back to Washington the next evening.

The Presidential aircraft landed at the airport north of the city at 1:30 p.m., Central Standard Time. After pausing to accept greetings from civic officials, the President and his party set out in a motor cavalcade to drive the twenty-six miles, through streets lined with happy citizens, to the base on the southeast edge of San Antonio.

At Brooks, the preliminary part of the program already was under way. The afternoon was mild and sunny, with a light wind that ruffled the notes of speakers on the platform. Some 10,000 spectators and invited guests were seated in folding chairs on the grass, in the semicircular plaza facing the headquarters building, or on the low banks beyond that bordered the driveway. Batteries of cameras were set up on a scaffold in one section of the park. Another section was reserved for the White House press corps.

While the audience waited for the President and his entourage, Major General T. C. Bedwell Jr., commander of the Aerospace Medical Division and host for the occasion, welcomed the visitors. He then introduced, as an honored guest, General Bernard A. Schriever, commander of the far-reaching organization to which the Division belonged, the Air Force Systems Command.

On behalf of Secretary Zuckert—who was at that moment approaching the business district of San Antonio in the procession of cars behind the President—General Schriever presented the Outstanding Unit Award of the Air Force to the School of Aerospace Medicine. The Award was accepted by Colonel Harold V. Ellingson, now the commander of the School.

The period covered by the citation was from November 1, 1957, just after the orbiting of the first artificial satellite around the Earth by the Soviet Union, to June 30, 1963. These were the six years just ended, in which the space effort of the United States had been formed and developed.

In fact, however, the Award was intended to recognize more than this relatively brief span of activity by the School in support of national policy. It was a means of calling attention to the pioneer research on conditions affecting man in space, growing out of studies pursued by the School since its inception in 1918, and

carried on systematically since the founding of the Department of Space Medicine in 1949.

The citation referred to the many persons associated with the School who had "by their collective efforts, self-sacrifice, and extreme dedication . . . formulated new concepts and performed original research of great national and international significance." It was the sum total of this achievement by the School, and by the laboratories now affiliated with it in the Aerospace Medical Division, that had brought the President of the United States to Texas on this fine November afternoon.

"Their accomplishments," the citation went on, "provided invaluable information, which served as a foundation for human flight at the extreme borders of the Earth's atmosphere and in interplanetary space, greatly strengthening the defensive posture of the United States and the free world."

The ceremony proceeded, while the Presidential party still was making slow progress through the city streets. Colonel Ellingson now presided at the rostrum.

To Lieutenant Colonel George L. Hahn, the medical construction liaison officer who had supervised the building of the newly occupied School facilities, Colonel Ellingson presented the Legion of Merit. Colonel Hahn was praised for his foresight in identifying and correcting potential problems in the construction program, before they had gone too far to be remedied.

Colonel Robert W. Martindale, Executive Officer of the School, soon to be reassigned overseas, received from Colonel Ellingson the Commendation Medal. Colonel Martindale was cited particularly for his part in planning for the design and equipment of the new laboratories, so that they would satisfy the needs of the scientists who were to use them.

The School commander then offered thanks and acknowledgements to a long list of other persons and agencies, including civilian contractors, who had contributed in various ways to the successful completion of the building program.

Finally there was a lull in the proceedings on the platform. A stir of activity at the fringes of the crowd around the Gate in-

dicated that the caravan of cars was approaching. The helicopters which had been landing nearby with last-minute visitors now were at rest on a grassy clearing. The time was 2:40 p.m., a little more than an hour since the President had stepped down from his plane at the Airport.

The open car bearing President and Mrs. Kennedy drove through the Gate swiftly, showing little more than the flash of sunlight on a bright head and a dark one. It circled around the driveway to the entrance on the far side of the headquarters building, where General Bedwell and his staff were waiting. The other cars quickly followed.

From a pair of busses behind the dignitaries, the White House press corps issued in haste and streamed across the lawn to the desks reserved for them at the side of the speaker's stand. There was another brief wait while the newsmen adjusted their typewriters and unfolded their cameras.

When the glass doors opened and the youthful Commander in Chief appeared on the platform, it was if he had been evoked by some feat of magic out of the brisk November air. Wearing a rather mischievous smile, he showed himself to the crowd for an instant, and then ushered Mrs. Kennedy deferentially to her chair.

The President's personal magnetism had never been more evident than it was at this moment. His deportment had an aura of infectious gayety that added grace to the task which he was performing. He gave the impression of being at the height of all his powers, supremely confident, enjoying himself and the effect that he produced on his audience.

In a few crisp words, General Bedwell introduced the Secretary of the Air Force, who introduced the President.

Mr. Kennedy's remarks were simple and non-partisan, addressed to the importance of space research in the future of the United States. After touching on the history of aviation since World War I at the pioneer bases around San Antonio, the President discussed some of the benefits which research in space medicine could be expected to bring in solving problems of health for the growing multitude of peoples on our planet.

FIGURE 24 --

The late President John F. Kennedy as he dedicated the modern complex of buildings which housed the School in 1963.

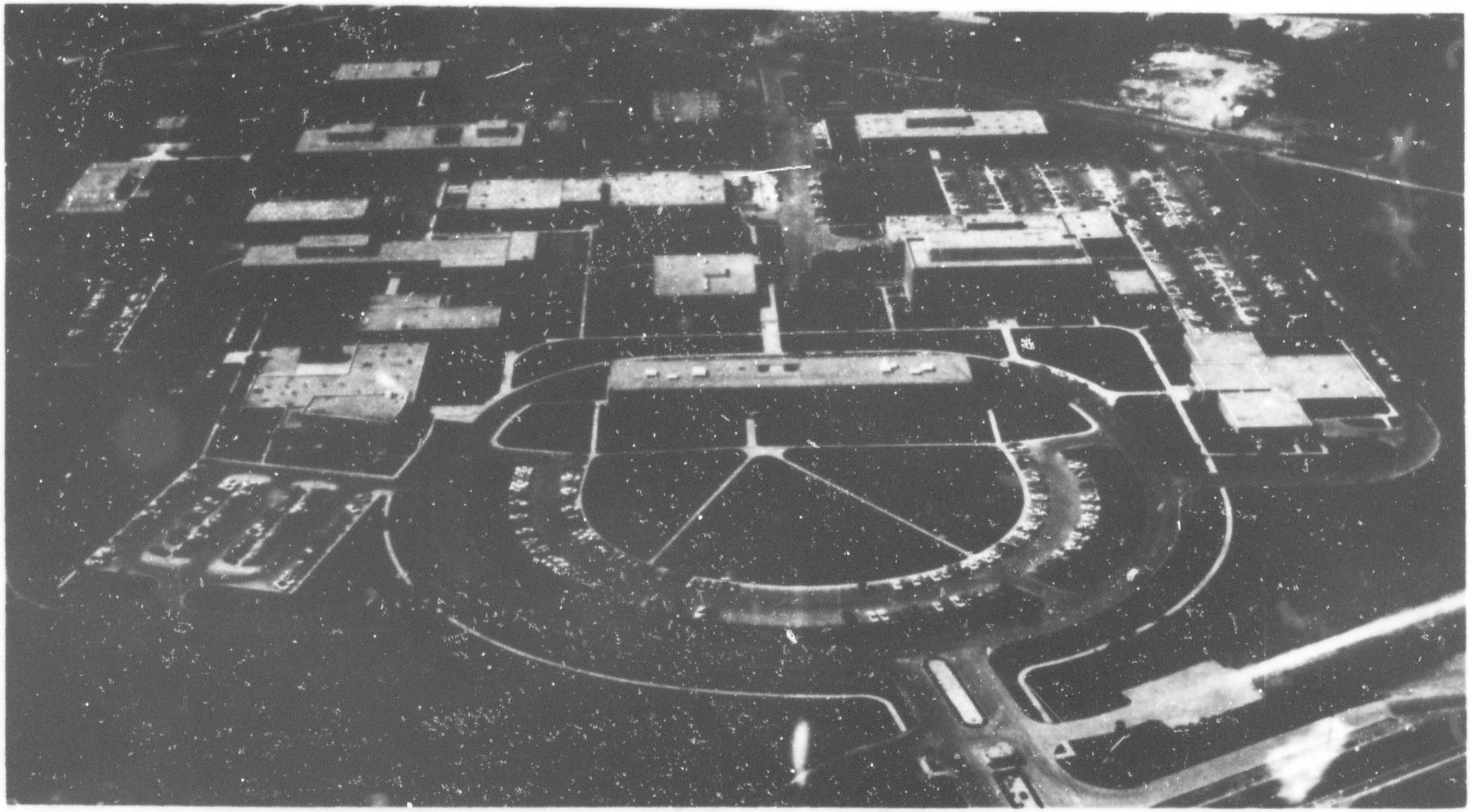

FIGURE 25 —

Today, the USAF School of Aerospace Medicine occupies this complex of buildings at Brooks AFB, Tex.

From the medical advances growing out of studies performed by the Aerospace Medical Division, Mr. Kennedy went on to the progress being made in the national space effort as a whole. He referred particularly to the powerful Saturn C-1 booster rocket developed for NASA by Dr. Wernher von Braun, then nearing its first operational test flight at the launching site which would so soon become known as Cape Kennedy.

The way ahead would be long and sometimes tedious, the President conceded, but the work would go on. To illustrate the determination with which the exploration of space was being carried forward, Mr. Kennedy recalled a passage which he had read in a book by an Irish author.

Said the President: "Frank O'Connor . . . tells . . . how, as a boy, he and his friends would make their way across the countryside. And when they came to an orchard wall that seemed too high . . . and too difficult . . . they took off their hats and tossed them over the wall—and then they had no choice but to follow. . . .

"This nation has tossed its cap over the wall of space—and we have no choice but to follow it. Whatever the difficulties, they will be overcome. Whatever the hazards, they must be guarded against. With the vital help of this aerospace medical center—with the help . . . and support of all Americans—we will climb this wall with safety and with speed. And we shall then explore the wonders on the other side."

After the dedication, President and Mrs. Kennedy went back through the headquarters building to the entrance, where they had arrived only a little while ago. Followed by the others in their party, they accompanied General Bedwell across the driveway and over a stretch of lawn, past the new Aeromedical Library, to the Altitude Laboratory. It was one of the research facilities occupied by the School of Aerospace Medicine just four years earlier.

There, in a horizontal steel cylinder designed originally as a low-pressure chamber, an experiment was under way. The cylinder had lately been remodeled as a laboratory version of a space cabin. Inside its stout walls, four young airmen were undergoing a month-long test in an atmosphere of almost pure oxygen, at a

pressure equivalent to an altitude of more than 5.2 miles, comparable to the thin air on the upper slopes of Mount Everest.

The experiment was one which the School had undertaken at the request of NASA. Project Mercury had been successfully concluded six months before, with the 34-hour orbital flight of Major Leroy Gordon Cooper Jr. in the space craft *Faith 7*. Now NASA was preparing for future missions ranging up to two weeks or more in the advanced Gemini and Apollo vehicles.

It was NASA's plan to provide essentially the same cabin atmosphere for the flyers in Gemini and Apollo that had sustained the Mercury astronauts. But the medical effects of breathing pure oxygen at this pressure, over periods of several weeks or longer, still were not fully known. Because the School had carried on similar studies for more than a decade, it had been asked by NASA to conduct these tests.

The four airmen—all between 17 and 19 years of age—were recent graduates of the basic military training course for recruits at nearby Lackland Air Force Base. They had volunteered for the experiment. On the afternoon of the President's visit to the laboratory, they had been locked away inside the cabin for ten days, working at tasks resembling those which a group of astronauts in orbit might have been called upon to perform. They still had twenty more days to go, before they would disperse to their duty assignments on the eve of Christmas.

In the vast room where the space cabin stood among the pipes, valves, and dials that controlled its exotic climate, Dr. Billy E. Welch, head of the Environmental Systems Branch, was waiting to brief the President. Younger even—by twelve years—than the Chief Executive, Doctor Welch was equally self-possessed. Stepping forward as the august company assembled, he explained the nature of the experiment in a few concise words.

With Mrs. Kennedy, the President approached an observation panel of thick glass in the side wall of the cabin. Inside, the airmen were attending to their tasks, unaware of the excitement in the room surrounding their small, remote world.

Doctor Welch offered the President a telephone headset, communicating with the interior of the cabin. Mr. Kennedy adjusted it over the celebrated shock of auburn hair. The movement at

the window caught the attention of one of the airmen, and he glanced up. His jaw dropped. He had recognized the familiar faces peering through the glass.

The mischievous smile returned to the President's countenance.

He said: "Hello."

Faintly, inside, the airmen said in unison: "Hello, Sir."

The President said: "How are you feeling?"

The airmen said: "Fine, Sir."

The President said: "How long have you been in there?"

The airmen told him: "Ten days, Sir."

The President said: "How much longer do you have to go?"

The airmen answered: "Twenty more days, Sir."

The President said: "Good luck."

The airmen said together: "Thank you, Sir. Good luck to *you*."

Mr. Kennedy removed the headset and turned back to Doctor Welch. Remembering the speech he had just made, he asked a question or two about ways in which the results of this experiment might be used to improve the nation's health. Doctor Welch mentioned some of the potential applications.

The President noticed a little band of assistants, who had edged into the room by a doorway to see the illustrious guest. He went over to them and shook their hands, with a few words of greeting and encouragement. Then he escorted Mrs. Kennedy out into the sunshine again. The visit was over.

The President's car had been brought around to a side door opening out of the laboratory, but it had been wedged into a crowd of spectators waiting to see the riders once more. Good-humoredly, the President guided Mrs. Kennedy through the crowd, clasping the many palms that were extended to him.

Still smiling, he handed Mrs. Kennedy into the car, and took his place beside her. Warily, the car was turned. It moved away at a dreamlike pace through the thinning multitude.

The motorcade formed again. Once more it circled the driveway, heading toward the Gate. This time it was bound for Kelly

Air Force Base, where the President's plane now waited after a short flight from the Airport. The time was about 3:20 p.m.

John Fitzgerald Kennedy had completed his last official act as President of the United States. Twenty-one hours and some minutes later, on another fine November afternoon in Dallas, he would be lying dead beside Mrs. Kennedy on the back seat of this same car, the victim of an assassin's bullets.

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Chapter 20

LOOKING FORWARD

The last years of General Bedwell's command were easier and more serene than the first.[1] This happy circumstance was largely a result of the policy which Air Force Headquarters had given him to carry out. The understanding and coöperation that grew up between the Aerospace Medical Division and NASA, if not perfect in all respects, was very much more intimate than it had been at the beginning. The two agencies now were working in unison toward the extension of man's knowledge and influence far out into space.

In part, the improvement in their relationship was (as General Bedwell had foreseen) a natural consequence of their close proximity on the plains of Texas. Neither could well ignore the other when they were, so to speak, neighbors separated only by a common fence. In part, too, it was brought about by the pointed action of the late President, John F. Kennedy, in choosing the aerospace medical institution as the site of his only major pronouncement on national policy during his all-too-brief sojourn in Texas.

Even before the President's trip, in October 1963, groups of high officials from NASA Headquarters in Washington had twice visited with General Bedwell and his staff at Brooks. Both had been led by Dr. Robert C. Seamans, Associate Administrator of the civilian space agency, and next in its chain of command after Mr. Webb and his Deputy Administrator, the greatly respected Dr. Hugh L. Dryden.

The first delegation, early in the month, had merely inspected the laboratories of the School, to see what facilities it offered for the research programs of NASA. The second, on the day before the President's arrival at Brooks, had explored specific proposals for experimental projects on which the two organizations could work together.

One immediate result of these conferences had followed in December, when NASA had opened a liaison office in the life sciences at the Division Headquarters. The representative chosen by NASA to manage this office was an Air Force pilot and psychologist, Lieutenant Colonel Henry Grady Wise, who had served for five years under General Roadman at Air Force Headquarters and later had joined him in the Washington headquarters of NASA.

The Division, too, had made some changes in its staff to encourage a closer rapport with NASA. One was the assignment of Lieutenant Colonel Stanley C. White, on the conclusion of his five-year stay with the Space Task Group of NASA at Langley Air Force Base and in Houston, as director of bioastronautics and systems support programs under General Bedwell's Deputy Chief of Staff for Research and Development.

As yet another sign of progress in their association, General Bedwell was able to announce publicly at the end of the year that research tasks carried on by the Aerospace Medical Division for NASA had risen from five to seventeen. The funds budgeted by NASA for these studies had increased by an even greater proportion. From an almost negligible sum of $187,000 a year earlier, they had grown to a respectable $913,000.

An even more important program, in its future requirement for the services of the Division, was made public by Secretary of Defense Robert S. McNamara in the final weeks of 1963. After five years of concentration solely on civilian space projects, the Administration had at last adopted one proposed by the Air Force. Known as the Manned Orbiting Laboratory, it was a plan to establish a large satellite vehicle in space above the Earth, to carry out scientific experiments bearing on the ability of human astronauts to perform various routine missions which were traditional peacetime military functions, such as observations of activities on the ground or rescue of crewmen from a damaged space craft.

Responsibility for the development and operation of the orbiting research laboratory was given to the Air Force Systems Command, which had conceived it. In turn, the Systems Command delegated the physical and engineering aspects of the program to

its Space Systems Division in Los Angeles, California, and the medical and biological aspects to the Aerospace Medical Division in Texas.

General Bedwell's organization would participate in the project in several different ways. First, it would supervise the development of life-support systems for the astronauts orbiting in the space laboratory itself. Then it would be the task of the Division to develop medical standards for the selection and training of the astronauts, as it now did for those of NASA. When the Laboratory was ready for launching, flight surgeons of the Division would monitor the crew's fitness from tracking stations on the ground, as they also did for NASA.

Moreover, it would be the responsibility of research scientists in the Division to devise medical and biological experiments which were uniquely possible in space (the long-term effects of weightlessness, for example, down to the cellular level) to be carried out by the crews in the orbiting laboratory. And, finally, it was probable that the Division's own staff would provide some of the astronauts. Just as it was the duty of the flight surgeon to take part in frequent missions by aircraft, in order to familiarize himself with the crew's problems and to give them medical care wherever they might be, so it was logical to expect that the flight surgeon would provide the same attention to crew members on an extended mission in space.

Orbiting in a vehicle a hundred miles or more above the Earth, for periods of several weeks or longer, the crew in the Laboratory would be far less accessible to routine medical treatment facilities than they would be anywhere in flight a few hundred feet above the ground. It was precisely for this reason that Doctor Lyster had conceived the function of the flight surgeon as an aeronautical rating, almost half a century before. The extension of manned flight to the regions high above the atmosphere had by no means done away with this basic human need.

Even before the public announcement of the Manned Orbiting Laboratory program, the School of Aerospace Medicine had ordered a new and more advanced model in its series of space cabins, for possible use in just such a project. A horizontal metal cylinder 19 feet in length and 9 feet in diameter, the new cabin was very

much more spacious than its predecessors had been. It was divided into three compartments, providing separate areas for simulated flight operations, for in-flight research programs, and for sleep, rest, and recreation. It would carry its own food and other supplies to support a crew of four men on a mission lasting thirty days or longer.

The most novel feature of the cabin was its double-shell construction. In the near-vacuum between the two walls, it would maintain a pressure environment closely approximating the medium surrounding a vehicle traveling through space. Any leakage of its internal atmosphere would be from the cabin to the vacuum around it, as on an actual space flight. In the past, leakage had been from the ground-level air of the laboratory in which it was housed, into the more tenuous atmosphere of the cabin itself. The new test chamber was delivered to Doctor Clamann at the School in August 1964, and the first experiments began early in November.

Meanwhile, General Bedwell had made some changes in the organization of the Division to strengthen its support of the Manned Orbiting Laboratory program. At the headquarters of the Space Sysems Division in Los Angeles, he established a branch office of his own headquarters, to coördinate the plans for medical and biological aspects of the program with those of the California division's engineers and scientists for the space vehicle in which they would be carried out.

The flight surgeon in charge of the Los Angeles office, as General Bedwell's staff Assistant for Bioastronautics and Aerospace Medicine, was Colonel Andres I. Karstens, a former Director of Research for the School when it had made its home at Randolph, and most recently commander of the Division's newly-acquired Aerospace Medical Research Laboratories at Wright-Patterson Air Force Base, Ohio.

Within the Aerospace Medical Division, twenty-two design-area coördinators were designated to supervise progress in research and development on the ninety or more individual tasks for which the Division now was responsible, and to channel the results to Doctor Karstens in Los Angeles. A round dozen of these coördinators, headed by Henning E. von Gierke, D. E., a specialist on biodynamics

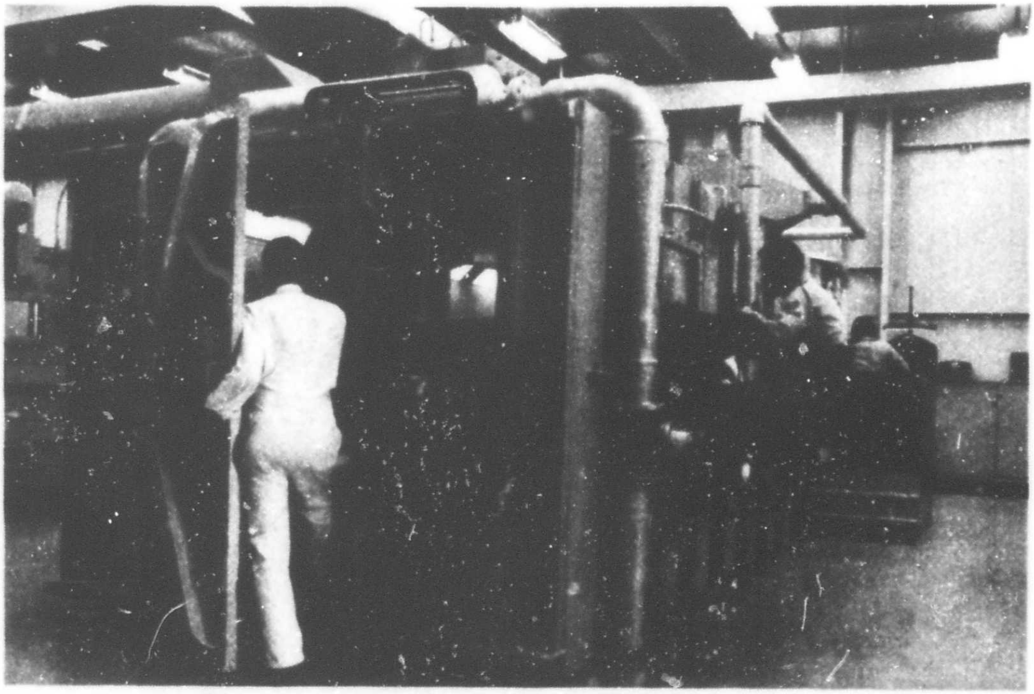

FIGURE 26 —

Modern day high altitude chambers at the USAF School of Aerospace Medicine can simulate an altitude up to 100,000 feet.

FIGURE 27 —

In December 1965, these four subjects underwent a 48-day test evaluating a helium-oxygen atmosphere.

FIGURE 28 —

This partial pressure suit developed at the School of Aerospace Medicine has been tested at simulated altitudes in excess of 115,000 feet.

in space flight, were staff members of the Laboratories at Wright-Patterson, which had been studying just such problems for the past thirty years, since General Armstrong had first inaugurated the medical engineering facility in Dayton.

Four of the coördinators were civilian scientists at the School of Aerospace Medicine, among them Billy E. Welch, Ph.D., in Doctor Clamann's department, and Lawrence E. Lamb, M.D., director of clinical sciences.

From Wilford Hall Hospital, the Division's treatment center at neighboring Lackland Air Force Base, two coördinators were chosen. They were Lieutenant Colonel John W. Ord (M.D.), chief of the cardiovascular service, and Major Gerald W. Parker (M.D.), chief of gastroenterology.

Two more coördinators came from the Division Headquarters at Brooks. These were Lieutenant Colonel Milford D. Harris Jr., director of Radiobiology programs in the office of the Deputy Chief of Staff for Research and Development, and Captain Duane E. Graveline, a flight surgeon conducting research in the office of the Deputy for Foreign Technology.

One coördinator, for psychological selection and training standards and operations, was Abraham Carp, Ph.D., technical director of the Personnel Research Laboratory at Lackland.

One area (biomedical measurements) was left open for the time being. Research and development in this area would require a new laboratory, jointly planned and operated by the School of Aerospace Medicine at Brooks and the Epidemiological Laboratory at Lackland. The program would begin later, after the new facility was established.

In the spring of 1964, General Bedwell was installed as President of the Aerospace Medical Association at its annual meeting in Miami Beach, Florida.[2] Thus he became the seventh in a list of eminent flight surgeons who had commanded the School of Aerospace Medicine, or one of its affiliates within the new Division, to serve also as head of the professional society that represented the specialty of flight therapy. His predecessors were Dr. Louis H. Bauer, Dr. Arnold D. Tuttle, General Reinartz, Dr. William Randolph Lovelace II, General Armstrong, and General Benson.

The Presidency of the Association was more than merely a personal honor for General Bedwell. It recognized him as the titular leader of the growing circle of practitioners within this unusual specialty, and their spokesman, not only in the United States but as well in the world at large.

For the past two decades or more, the Association had included on its membership roster specialists in aviation medicine of other nations, and had chartered a number of local chapters in Europe and elsewhere overseas. Nearly all of these members—many of them outstanding leaders of the profession in their own countries—were graduates of the School of Aerospace Medicine who had carried its techniques back to the regions from which they came, and there had instituted the same studies and procedures in their military services and civil airlines.

Since World War II, the School's medical alumni abroad had spread from a few scattered representatives in Latin America, China, and the Philippines to include every major country outside the Soviet sphere of influence on every continent of the world, and to some of the newer nations emerging from colonial dependency besides.

Beginning in 1948, the School had trained medical officers from the air forces of France and Great Britain until both allies had established similar institutions, modeled on the one then at Randolph Air Force Base and now at Brooks. Later on, its student officers had come from Belgium, Denmark, Finland, Greece, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and Turkey. Virtually the entire medical service of the renascent West German Luftwaffe had received its instruction in aerospace medicine from the School. Four medical officers from Yugoslavia had attended the course.

Looking farther abroad, the School had given its training to physicians from Afghanistan, Egypt (later the United Arab Republic), India, Iran, Iraq, Israel, Pakistan, Saudi Arabia, and the Union of South Africa. In the next year or so, it would graduate two officers from Nigeria.

In the Far East, its students had come from such widely separated points in culture and geography as Australia, Burma,

Indonesia, Laos, Thailand, and Vietnam. The graduates from Korea and Japan now were second in number only to those from the West German Republic.

Altogether, by 1967, a total of 53 countries in othe[illegible]s of the world would have sent their medical officers to Texas [illegible]ining in aerospace medicine. The graduates would come to [illegible]early 600—more than the entire roster of flight surgeons in the United States who had received this specialized instruction from the School up to 1940, on the eve of America's entry into the War.

A great many of these physicians were among the international membership of the Aerospace Medical Association. They were the professional colleagues around the world who welcomed General Bedwell as an outstanding authority on the care of flyers, when he went abroad to represent the Association or the Aerospace Medical Division, or both, at international scientific meetings.

In another way, the global character of the influence exerted by the Division and the School was demonstrated toward the close of 1964. In November, the Division presented its third international Symposium on Bioastronautics and the Exploration of Space. Again the scene of the meeting was the Granada Hilton Hotel in downtown San Antonio. Again the arrangements were handled by the Southwest Research Institute. Again the program offered an impressive collection of papers by eminent specialists on varied aspects of space flight from the United States and Europe.

The 1964 Symposium, however, was a spectacular attraction for another reason. For the first time at any large public gathering, sponsored by the military services in the United States, it included among the participants three ranking medical scientists associated with space research and operations of the Soviet Union.[8] The Soviet speakers, all physicians, were Dr. Oleg G. Gazenko, a physiologist from the Academy of Sciences in Moscow; Dr. V. V. Antipov, a radiobiologist, also from the Academy of Sciences; and Dr. M. M. Kasenkov, an ophthalmologist, from the Institute of Normal and Pathological Physiology in Moscow.

All three scientists were exceptionally frank and open in presenting their data and the conclusions derived from them. Doctor Gazenko discussed the life-support and other systems in the seven

manned Vostok and Voskhod space craft launched by the Soviet Union up to that time, with the effects of the flights on the cosmonauts. Doctor Antipov spoke on the biological experiments carried out during the flights, and what they revealed of the space environment. Doctor Kasenkov, reading a paper which he had written in collaboration with an associate, A. P. Kuz'minov, M.D., described the accuracy and the limitations of the visual observations performed by the cosmonauts.

The striking fact about these reports was that they accorded so well with the results obtained by American scientists, not only from the recent Mercury flights but also from preliminary studies made by the School of Aerospace Medicine, the Aeromedical Research Laboratory at Holloman, and other units now contained in the Aerospace Medical Division, over the previous fifteen years or more. It was apparent from these comparisons that the Soviet and American space programs were pursuing generally parallel paths toward similar conclusions. The Soviet lead was primarily in operational technology, not in medical science.

Shortly after this meeting, in January 1965, the increase in intensity of the fighting in Vietnam, and the consequent build-up of the American forces engaged there, began to be noticeable on the home front.[4] The most immediate effects on the Aerospace Medical Division were twofold. As usual in times of war, they were felt first in the reassignment of experienced medical officers and technicians—who naturally were key personnel of the Division and of its subordinate units—to the combat theatres, and in the stepped-up training of younger additions to their ranks, to care for the sick and wounded overseas. Thus the weight of the changes fell most heavily on the Division Headquarters and its larger components, the School of Aerospace Medicine and the Wilford Hall Hospital at Lackland.

The highest-ranking medical officer to feel this impact was Brigadier General James W. Humphreys Jr., commander of the Hospital for the past five years. On May 14, 1965, General Humphreys was relieved of his command at Lackland and was ordered to Saigon. His assignment there was in a civilian medical capacity with the State Department's Agency for International Development, as Director of the Health Division of the United States Operating Mission in Vietnam. (The object of the Mission

FIGURE 29 —

The problems of feeding a man in space are under constant study at the School. Here a complete meal that has been pulverized and compressed into sticks is eaten by a subject in one of the studies.

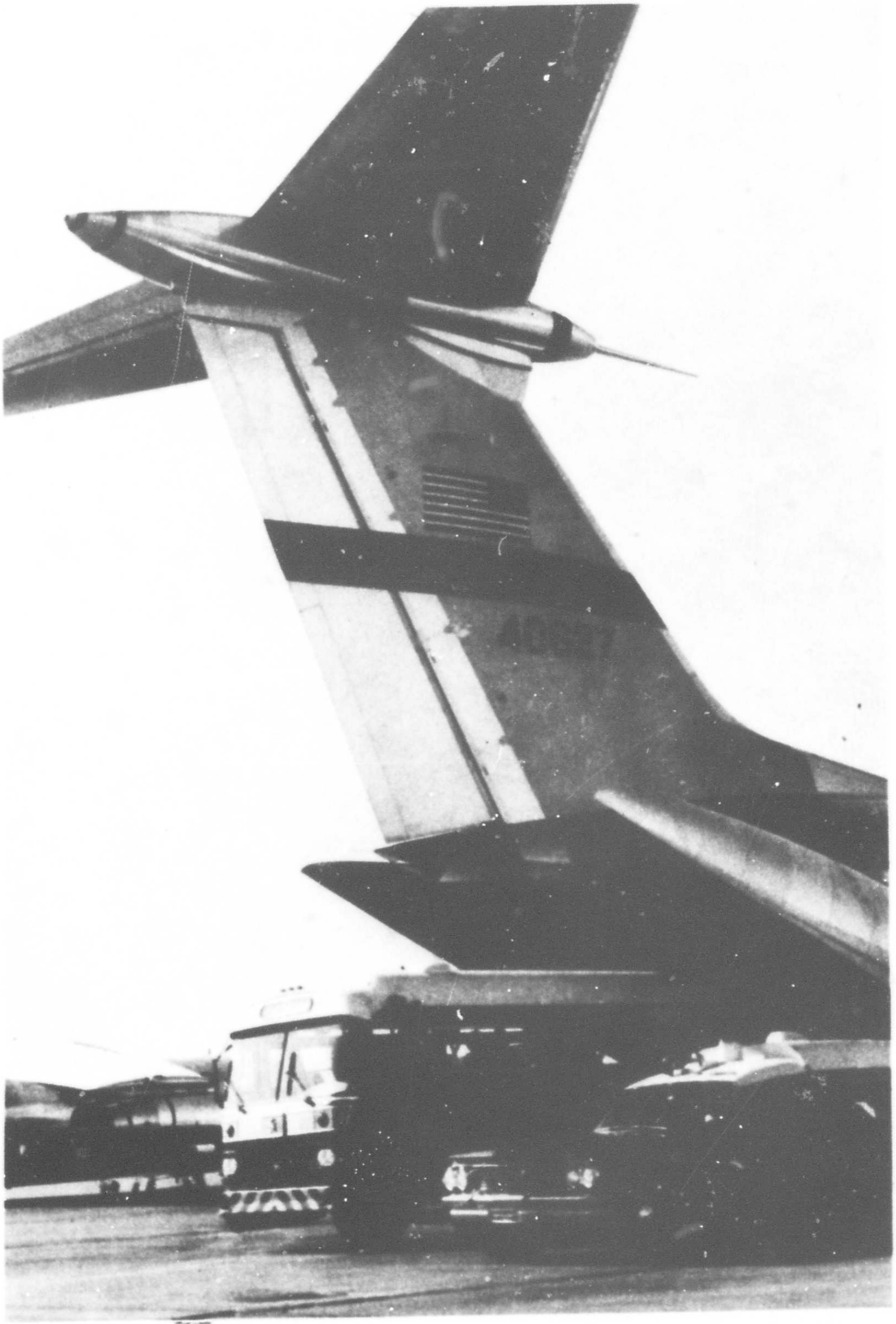

FIGURE 30 —

Since 1966 the C-141 Starlifter has been the mainstay of the aeromedical evacuation system.

was primarily to assist the local medical authorities in the treatment of civilians.)

General Humphreys' replacement in command of the Hospital was Brigadier General Thomas H. Crouch, most recently Director of Medical Staffing and Education in the office of Lieutenant General Richard L. Bohannon, the Air Force Surgeon General in Washington.

Already in Saigon when General Humphreys arrived there was a surgical team of seven key medical officers and assistants from the Hospital. They included Colonel Daniel C. Campbell Jr., former chairman of the Department of Surgery; Captain Richard A. Heimburger from the same department; Captain Joseph H. Goff, a nurse-anesthetist; Captain Dearld L. Tusler and Lieutenant Richard I. Waring, surgical nurses; and Staff Sergeants Lonnie C. Empey and Robert O. Franz, both medical attendants.

Hardly had General Humphreys stepped down off the plane in Vietnam when he accomplished a feat that made news in the press at home. With Doctor Campbell as his assistant, he successfully removed a live grenade which had lodged in the back of a Vietnamese farmer, operating with instruments attached to a steel arm inserted through an opening in a pane of bullet-proof glass to reduce the effects of a possible explosion.

In addition to staff members like General Humphreys, who were lost permanently to the needs of the fighting forces in Southeast Asia, the Division sent a number of its key officers on lengthy tours of the war theatre as observers, to report on the medical problems of the Air Force squadrons engaged there. One of these was Colonel Harold V. Ellingson, commander of the School of Aerospace Medicine and President-elect of the American College of Preventive Medicine, which supervised the maintenance of professional standards in the specialty of aerospace medicine.

Others besides Colonel Ellingson who traveled across the Pacific on inspection trips were two of his fellow medical officers, Lieutenant Colonel Elmer V. Dahl, commander of the Epidemiological Laboratory of the Division at Lackland, and Lieutenant Colonel Paul W. Musgrave, director of aerospace medicine programs in the office of the Deputy for Research and Development at Division

Headquarters, and a medical administrator, Lieutenant Colonel Michael M. Conrad, director of medical services in the office of the Division's Deputy for Medicine and Education.

As an incidental result of Colonel Dahl's expedition, the Division was to acquire another subordinate unit in the next few months, more remote even than the Laboratory in Alaska. It was the Fifth Epidemiological Flight of the Pacific Air Forces at Clark Air Base in the Philippines. Transferred administratively to the Systems Command for assignment to the Aerospace Medical Division, and geographically from Clark Air Base to a more modern laboratory in Manila, where it would become the responsibility of Colonel Musgrave who was named as its commander.

The Division also supported the Southeast Asia War with a number of important developments in operational equipment for the use of medical units and combat flyers serving in the field. Urgently requested by the organizations for which they were intended, these devices were supplementary to the regular research and development programs of the Division, and took precedence over them.

Late in November 1965, word arrived at Brooks that General Bedwell was about to be reassigned, after five years as commander of the Aerospace Medical Division and its predecessor organization, the Aerospace Medical Center. His next duty was to be in the office of the Assistant Secretary of Defense for Health and Medicine, in Washington.

The first advice as to his successor was that the next commander would be General Humphreys, on the conclusion of his one-year tour with the Agency for International Development in Saigon. Then the news was forwarded that General Humphreys had volunteered to extend his term in Vietnam for another year.

Shortly afterwards, still another unofficial report was received. It was that NASA had put in a strong request for the assignment of General Humphreys to that organization as Director of Aerospace Medicine, the position that General Roadman had held until his recent appointment as Surgeon of the Air Defense Command in Colorado Springs, Colorado. NASA was prepared to wait another year for General Humphreys, if necessary, but not to accept another officer in his place.

So the assignment of General Humphreys to command the Aerospace Medical Division was canceled, and Air Force Headquarters looked around for a qualified commander to succeed General Bedwell. Meanwhile, the interim replacement was to be General Crouch, who had only taken charge of Wilford Hall Hospital a few months earlier, on the departure of General Humphreys. Command of the Division would be additional duty for General Crouch until a permanent successor to General Bedwell was found.

In January 1966, General Bedwell regretfully turned over his command to General Crouch and left for Washington. General Crouch added the management of the Division to his duties, commuting daily from his quarters at Lackland. As a highly knowledgeable assistant on the spot, he had the services of Colonel George E. Schafer, Vice Commander of the Aerospace Medical Division for the past three months, and before that Vice Commander of the School of Aerospace Medicine.

Though he was not yet 40 years old, Doctor Schafer had acquired impressive experience in all the facets of the Division's activity—research and development, clinical practice, and teaching. With training as a specialist in surgery as well as in aerospace medicine, he had served as the first flight surgeon of an American jet fighter group and had commanded Air Force hospitals both in Germany and in the United States.

From the Air War College, where he had been named as an outstanding graduate, Colonel Schafer had joined the Aerospace Medical Division four years earlier as administrative assistant to the Deputy Chief of Staff for Research and Development, with management responsibility for Human Factors programs of the Air Force. Later appointed Deputy Chief of Staff for Operations (which included the teaching programs at the School and at the Hospital), he had gone from that position to the School as Vice Commander.

Thus General Crouch, whose background was largely clinical, could draw on the familiarity of his assistant with every detail of the Division's work.

The interregnum was to last only four months. On May 15, the permanent commander of the Division arrived at Brooks to

relieve General Crouch. He turned out to be the same officer whose former post with NASA was being held for General Humphreys: Brigadier General (later advanced to Major General) Charles Harvey Roadman, once a department head of the School at Randolph under General Armstrong, and more recently a specialist on research and development in aerospace medicine at Air Force Headquarters as well as with NASA Headquarters in Washington.

General Roadman was, incidentally, only the second officer to command the Division or the School from which it had sprung who was a rated pilot as well as a flight surgeon. The first had been Colonel Fabian L. Pratt, a quarter of a century before.

A more logical choice than General Roadman could not have been made to carry on the policy of full coöperation with NASA that the Air Force had adopted. NASA was now midway through the operational phase of its second manned flight program, Project Gemini. The Gemini space craft was an enlarged version of the original Mercury vehicle that NASA had acquired from the Air Force, carrying two astronauts rather than one. It was launched by the more powerful Titan II booster which the Air Force had developed as a successor to Atlas, and which would be used by the Air Force too—in a still more powerful version—to launch the Manned Orbiting Laboratory.

Thus the two space programs were advancing together along adjoining paths, meeting many of the same technical and human problems, and sharing much of the same equipment, research, and operational experience. The results of both would be applicable later to Project Apollo, the American plan to send a team of three astronauts to the Moon and back before 1970, landing two of them for a brief inspection of the lunar surface.

By November 1966, when NASA wound up the Gemini flight program after twenty months and ten orbital missions, an impressive list of practice manoeuvres in preparation for Project Apollo had been accomplished. For the first time, pairs of Gemini astronauts had not merely guided the space craft on its predetermined course, but had besides performed the difficult feat of changing its path from one orbit to another. For the first time in the American program, they had left the shelter of their hermetically

sealed cabin to drift along beside the craft in the same orbit, weightless, while they carried out certain extravehicular tasks on their own in space.

They had made the longest single flight beyond the atmosphere so far: 330.6 hours, just short of two weeks, the time it would have taken them for the round trip to the Moon. And they had shown that they could accomplish the most difficult exercise of all—a rendezvous in space between two vehicles flying different patterns, joining them together ("docking") so that the astronauts could transfer from one to the other.

All of this had been done without loss of life or injury to any of the sixteen astronauts involved. (Four of the astronauts had each flown two missions.) The program had not been without its unexpected hazards. On several occasions near-fatal incidents had occurred. But, in each case, the resourcefulness of the pilots themselves had sufficed to bring the mission home safely. The superiority of human intelligence and dexterity over any built-in systems of mechanical ingenuity had been amply demonstrated.

Three months after the successful completion of Project Gemini, a double disaster *did* strike the American space program. At Cape Kennedy, Florida, on January 27, 1967, during a routine ground test of the first Apollo space craft with its three designated crew members aboard, a flash fire blazed up in the cabin, destroyed its interior fittings, and killed the astronauts before they could be extricated. Four days later, at Brooks Air Force Base, in the course of a routine experiment to test the effects of the cabin atmosphere used in all American space craft up to this time, a similar fire raced through the chamber and killed two young airmen who were assisting in the project.

The astronauts who died at Cape Kennedy were Air Force Lieutenant Colonel Virgil I. Grissom, veteran of the first Gemini mission as well as of an earlier sub-orbital flight in the Mercury series; Air Force Lieutenant Colonel Edward H. White II, son of a retired Air Force general, pilot of the second Gemini flight, and the first American to venture outside a space craft in orbit; and Navy Lieutenant Commander Roger B. Chaffee, training for the Apollo mission as his first assignment with NASA.

The technicians lost at Brooks were Airman Third Class William F. Bartley Jr. and Airman Third Class Richard G. Harmon. Both were experienced medical assistants in the space research program. Both were 20 years old.

The accidents originated from the same basic cause. A short circuit of the wiring in the cabin had touched off a spark, which had exploded into flame with extraordinary speed and intensity in the oxygen-rich atmosphere of the crew's compartment. In a few seconds, before the exit hatches could be opened or the fire extinguished, every combustible object in the cabin had been consumed.

The highly flammable character of an atmosphere consisting largely or entirely of oxygen—one of the most volatile of gases, had been known to specialists in aerospace medicine for thirty years or longer.[5] General Armstrong had remarked on it in describing the reasons for the use of a normal oxygen pressure in the gondola of the balloon *Explorer II* in 1935. Doctor Clamann, at the School of Aerospace Medicine, had discussed the problem in published papers going back to 1940.

But NASA had no alternative to the selection of an oxygen-rich atmosphere for the Gemini and Apollo space craft. In addition to the engineering limitations on weight and structural integrity of the space craft, a purely medical consideration had dictated the choice. One requirement of the Apollo mission was that the astronauts should leave the craft during the flight, not only to transfer from one otherwise inaccessible component of the vehicle to another, but also to explore the airless surface of the Moon The pressure suit which they would wear on these extra-vehicular excursions necessarily provided a minimum atmospheric pressure consisting of pure oxygen. To avoid the crippling effects of decompression sickness during the change from cabin to suit, the pressure in both would have to be the same.

So the use of an oxygen-rich atmosphere was unavoidable in the early phases of the American space program, until a very much larger and more powerful launching vehicle could be developed. The fire hazard had been fully known and accepted by the astronauts as a professional risk of the kind which they had been accustomed to take in flight-testing new aircraft within the

atmosphere and which they were prepared to face in the space program, along with the indescribable satisfaction they derived personally from their participation in it.

Some additional safeguards could be—and promptly were—designed and built into the craft by NASA, at a critical cost in weight allotted to other flight systems and at the possible expense of delaying the expedition to the Moon by several months or years while the Soviet Union was pressing on with its plans for the same scientific achievement. But certain dangers—of which this was one—were inherent in the project itself, and could not be wholly eliminated. Both NASA and its partners in the Aerospace Medical Division paused to honor the dead. Then they went on with their work, as pioneers have always done, wherever they have gone to open up the wilderness.

At Brooks, during these events, nothing had changed significantly except that Colonel George E. Schafer, after more than a year as General Roadman's vice commander for the Division, had become Commander of the School. (He was the seventeenth in a line of succession that had begun with Colonel William H. Wilmer's appointment in the fall of 1917.)

As the year 1967 approached its end, the art of lofting man-made vehicles into space was hardly a decade old, dating from the first launching of a Soviet Sputnik in the last quarter of 1957. Aerospace medicine, which had made it possible for men to fly these vehicles, was considerably older. It was about to celebrate its first half-century.

Yet age, like every other feature of the living universe that men inhabited, was measured in relative terms. The Moon, for example, had been Earth's close companion for something like seventy million centuries, and an object of human speculation for as long as intelligent life had existed on this planet. And still it was waiting to receive the first visit from its neighbor.

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APPENDIX I

MEDICAL RESEARCH LABORATORY: ORIGINAL STAFF, JANUARY 19, 1918

COMMAND ADMINISTRATION

Major William H. Wilmer (M.D.), Officer in Charge
Major Edward G. Seibert (M.D.), Executive Officer
Lieutenant W. Harvey Kernan, Adjutant (Additional Duty)
Lieutenant Howard H. Spalding, Supply Officer

OPHTHALMOLOGY

Captain Conrad Berens, Jr. (M.D.), Director
Captain Elbert S. Sherman (M.D.)
Lieutenant Henry R. Skeel (M.D.)

EAR-NOSE-THROAT

Major Eugene R. Lewis (M.D.), Director
Captain Henry W. Horn (M.D.)

CARDIOVASCULAR

Captain James L. Whitney (M.D.), Director

NEUROPSYCHIATRY

Major Stewart Paton (M.D.), Director

PHYSIOLOGY

Captain Edward C. Schneider (Ph.D.), Director
Lieutenant George F. Hanson
Lieutenant W. Harvey Kernan
Lieutenant Harold F. Pierce

PSYCHOLOGY

Major Knight Dunlap, Director
Lieutenant English Bagby
Lieutenant Floyd C. Dockeray
Lieutenant Schachne Isaacs
Lieutenant Prentice Reeves

APPENDIX II

FLIGHT SURGEONS DESIGNATED IN 1918

Captain Murdock Bannister
Major Wilson M. Bassett
Charles O. Bayless
Major Albert F. Beverly
Major Theodore S. Blakesley
Captain Eugene Cary
Captain Frank Cary
Captain Kosciusko W. Constantine
George E. Frothingham
Captain John P. Gallagher
Colonel Ralph H. Goldthwaite
Major Robert R. Hampton
Major Henry W. Horn
Captain Robert J. Hunter
Major Charles W. Hyde
Captain Edwin S. Ingersoll
Major Isaac H. Jones
Charles W. Kollock
Captain Louis Levy
Captain Frederick C. Lewitt
Major Andrew W. McAlester
Major Robert S. McCombs
Major James H. McKee
John O. McReynolds
Major William C. Meanor
Major William F. Patten
Major Richard W. Perry
Captain John B. Powers
Major William R. Ream
William A. Scruton
Captain Robert A. Trumbull
Lieutenant Claude T. Uren

APPENDIX III

MEDICAL MISSION TO THE A. E. F., AUGUST 1918

Colonel William H. Wilmer, Officer in Charge
Lieutenant Colonel Leonard G. Rowntree

Major Wilson M. Bassett
Major Albert F. Beverly
Major Theodore S. Blakesley
Major Kosciusko W. Constantine
Major John P. Gallagher
Major Robert R. Hampton
Major Henry W. Horn
Major Charles W. Hyde
Major Edwin S. Ingersoll
Major Andrew W. McAlester
Major Robert S. McCombs
Major William C. Meanor
Major William F. Patten
Major Richard W. Perry
Major Edward C. Schneider
Major James L. Whitney
Captain Conrad Berens, Jr.
Captain George D. Carter
Captain Eugene Cary
Captain Floyd C. Dockeray
Captain Frank M. Hallock
Captain Harold F. Pierce
Captain John B. Powers
Captain Henry R. Skeel
Captain Robert A. Trumbull
Captain Claude T. Uren
Lieutenant Paul A. Garber
Lieutenant Harold W. Gregg
Lieutenant George F. Hanson
Lieutenant Schachne Isaacs
Lieutenant W. Harvey Kernan
Lieutenant Prentice Reeves

APPENDIX IV

MEDICAL RESEARCH LABORATORY: STAFF REMAINING, AUGUST 1918

COMMAND ADMINISTRATION

Lieutenant Colonel Edward G. Seibert (M.D.), Acting Officer in Charge
Lieutenant Howard H. Spalding, Supply Officer

OPHTHALMOLOGY

Captain Elbert S. Sherman (M.D.), Director
Captain Percival Dolman (M.D.)
Captain Joseph F. Grant (M.D.)
Captain Harvey J. Howard (M.D.)

Captain H. L. Underwood (M.D.)
Lieutenant James N. Buchanan (M.D.)
Lieutenant E. B. Goodall (M.D.)
Thomas F. Bridgman
T. R. Donnelly
Raymond S. Goux
James D. Jackson
Roy C. Lowe
William W. Sauer
Arthur W. Stevenson
Francis W. Thomas
William B. White

EAR-NOSE-THROAT

Lieutenant Colonel Eugene R. Lewis (M.D.), Director
Captain Percy W. Cobb (M.D.)
Captain James J. King (M.D.)
Frank L. Dennis
Lewis Fisher
Earnest De W. Wales

NEUROPSYCHIATRY

Major Stewart Paton (M.D.), Director
Captain William MacLake (M.D.)
Captain Ira F. Peak (M.D.)
Lieutenant Jaime de Angelo (M.D.)

CARDIOVASCULAR

Captain Arthur C. Bachmeyer (M.D.)
Captain Nathan S. Davis (M.D.)
James L. Blair
Donald D. Johnston
John R. Kleyla
Fedor L. Sanger

PHYSIOLOGY

Captain Reuben A. Johnson, Director
Captain George B. Obear
Captain Verner T. Scott (M.D.)
Lieutenant Max M. Ellis (Ph.D.)
Lieutenant Carl N. Larsen (M.D.)
Lieutenant Brenton R. Lutz
George W. Dennis
Harry Fried
Charles W. Greene
Paul B. Jenkins
George P. Rawls

PSYCHOLOGY

Major Knight Dunlap, Director
Captain Harry M. Johnson
Lieutenant English Bagby
Madison Bentley
Fred L. Wells

APPENDIX V

MEDICAL RESEARCH LABORATORY: POSTWAR STAFF, 1920

COMMAND ADMINISTRATION

Major Louis H. Bauer (M.D.), Officer in Charge
Lieutenant Frederick S. Simmons, Executive Officer

AVIATION MEDICINE

Captain John B. Powers (M.D.), Director

OPHTHALMOLOGY-OTOLOGY

Major Lloyd E. Tefft (M.D.), Director
Captain Percy W. Cobb (M.D.)
Miss Mildred W. Loring, Research Assistant
Miss Elizabeth K. Stark, Research Assistant

NEUROPSYCHIATRY

Major William MacLake (M.D.), Director
Captain Ira F. Peak (M.D.)

PHYSIOLOGY

Edward C. Schneider, Ph.D., Director
Mr. Robert W. Clark, Research Assistant
Miss Geneva Crawford, Research Assistant
Mr. Archer L. Hurd, Research Assistant
Miss Dorothy Truesdell, Research Assistant

PSYCHOLOGY

Miss Barbara Valette Deyo, Director

APPENDIX VI

AIR CORPS FLIGHT SURGEONS, SEPTEMBER 14, 1926

PILOTS

Captain Charles V. Hart, Brooks Field, Texas
Captain Alexander Mileau, Brooks Field, Texas
Captain Fabian L. Pratt, Fort Riley, Kansas
Captain Andrew W. Smith, Bolling Field, D. C.

JUNIOR PILOTS

Major Robert A. Hale, McCook Field, Ohio
Captain John P. Beeson, Luke Field, Hawaii
Captain Percy D. Moulton, Clover Field, California

NON-PILOTS

Lieutenant Colonel William R. Davis, The Chief Surgeon, Washington, D. C.
Major Cadmus J. Baker, Chanute Field, Illinois
Major Edward P. Beverley, France Field, Canal Zone
Major Frank R. Borden, Maxwell Field, Alabama
Major John F. Duckworth, Scott Field, Illinois
Major Edward C. Greene, Brooks Field, Texas
Major Raymond F. Longacre, Clark Field, The Philippines
Major Irwin B. March, Mitchell Field, New York
Major Francis H. Poole, Brooks Field, Texas
Major Benjamin B. Warriner, Langley Field, Virginia
Major William E. Wilmerding, Fort Wayne, Michigan
Major Wood S. Woolford, Assistant Chief Surgeon, Washington, D. C.
Captain Lowyd M. Ballantyne, Selfridge Field, Michigan
Captain Dalmar R. Blakely, Langley Field, Virginia
Captain Charles E. Brenn, Fort Crockett, Texas
Captain James F. Brooke, Mitchel Field, New York
Captain Samuel E. Brown, Kelly Field, Texas
Captain Charles T. C. Buckner, Fairfield, Ohio
Captain Shores E. Clinard, France Field, Canal Zone
Captain Tate R. Collins, Selfridge Field, Michigan
Captain Louis M. Field, Rockwell A. I. D., California
Captain Harrison H. Fisher, Scott Field, Illinois
Captain Michael G. Healy, McCook Field, Ohio
Captain Levy S. Johnson, Fort Sam Houston, Texas

Captain Benjamin W. Lewis, Kelly Field, Texas
Captain Neely C. Mashburn, Brooks Field, Texas
Captain Thomas H. Miller, Wright Field, Ohio
Captain David A. Myers, Crissy Field, California
Captain Ira F. Peak, Langley Field, Virginia
Captain Byron J. Peters, Luke Field, Hawaii
Captain Orlando J. Posey, Chanute Field, Illinois
Captain Eugen G. Reinartz, Bolling Field, D. C.
Captain Charles F. Shook, Honolulu, Hawaii
Captain Robert K. Simpson, Brooks Field, Texas
Captain Hubert S. Steenberg, Langley Field, Virginia
Captain Frederick H. Thorne, Brooks Field, Texas
Captain Frank C. Venn, Richards, Field, Missouri
Captain Paul S. Wagner, Kelly Field, Texas
Captain Thomas F. Weldon, Fort Sill, Oklahoma
Captain Lyle C. White, Boston Airport, Massachusetts
Captain William M. White, Camp Nichols, The Philippines

APPENDIX VII

AVIATION MEDICAL EXAMINERS, DEPARTMENT OF COMMERCE, FEBRUARY 1927

Dr. John V. Allen, Philadelphia, Pennsylvania
Dr. Harold N. Anderson, Woodbine, Iowa
Dr. Serge Androp, Gallipolis, Ohio
Dr. Edward H. Bedrossian, Philadelphia, Pennsylvania
Dr. Conrad Berens, Jr., New York, New York
Dr. David S. Brachman, Detroit, Michigan
Dr. James C. Braswell, Tulsa, Oklahoma
Dr. John S. Chase, Denver, Colorado
Dr. Joseph K. Cowherd, Cumberland, Maryland
Dr. Thomas J. Cross, Fort Worth, Texas
Dr. A. C. Downing, Des Moines, Iowa
Dr. Charles H. Gowan, Glendale, California
Dr. Maurice L. Greene, St. Louis, Missouri
Dr. Ralph N. Green, Jacksonville, Florida
Dr. Albert J. Herbolsheimer, Minneapolis, Minnesota
Dr. Josiah B. Hibbis Jr., Nashville, Tennessee
Dr. Bernard L. Jarman, Washington, D. C.
Dr. Edmund L. Jones, Wheeling, West Virginia
Dr. Luther H. Kice, Hempstead, New York
Dr. Bender B. Kneisley, Hagerstown, Maryland

Dr. Elmer E. Langley, Spokane, Washington
Dr. George L. Laverty, Harrisburg, Pennsylvania
Dr. Delivan A. MacGregor, Wheeling, West Virginia
Dr. Wade H. Miller, Kansas City, Missouri
Dr. Samuel E. Mitchell, Muskogee, Oklahoma
Dr. David D. Moncrief, Atlanta, Georgia
Dr. George E. Morris, Dallas, Texas
Dr. Louis D. Pawelek, Houston, Texas
Dr. William W. Pearson, Des Moines, Iowa
Dr. Edgar E. Poos, Detroit, Michigan
Dr. Gilbert E. Seaman, Milwaukee, Wisconsin
Dr. George O. Sharrott, Cumberland, Maryland
Dr. Mazel Skolfield, Salt Lake City, Utah
Dr. Wilbur F. Smith, Indianapolis, Indiana
Dr. William B. Smith, Hartford, Connecticut
Dr. Samuel M. Strong, Miami, Florida
Dr. John A. Tamisiea, Omaha, Nebraska
Dr. Frederick C. Warnshuis, Grand Rapids, Michigan
Dr. Edwin B. Winnett, Des Moines, Iowa

APPENDIX VIII

COMMANDERS, SCHOOL OF AEROSPACE MEDICINE AND MEDICAL ORGANIZATIONS INCLUDING IT AS A UNIT, 1918-1967

MEDICAL RESEARCH LABORATORY, U.S. ARMY SIGNAL CORPS

Colonel William H. Wilmer, January 1918-March 1919
Major Louis H. Bauer, March 1919-November 1922

SCHOOL OF AVIATION MEDICINE

Major Louis H. Bauer, November 1922-August 1926
Major Francis H. Poole, December 1926-August 1930
Major Benjamin B. Warriner, September 1930-September 1932
Lieutenant Colonel Albert P. Clarke, September 1932-August 1933
Lieutenant Colonel Arnold D. Tuttle, May 1934-November 1937
Lieutenant Colonel Coleridge L. Beaven, November 1937-February 1939
Lieutenant Colonel Fabian L. Pratt, March 1939-September 1941
Brigadier General Eugen G. Reinartz, October 1941-July 1946
Brigadier General Harry G. Armstrong, July 1946-June 1949
Brigadier General Otis O. Benson Jr., July 1949-April 1953
Brigadier General Edward J. Kendricks, May 1953-February 1956
Major General Ois O. Benson Jr., August 1956-August 1960
Colonel Robert H. Blount, August 1960-May 1961

SCHOOL OF AEROSPACE MEDICINE

Colonel Robert H. Blount, May 1961-January 1962
Colonel Paul A. Campbell, February 1962-December 1962
Colonel Harold V. Ellingson, January 1963-April 1966
Colonel James B. Nuttall, April 1966-June 1967
Colonel George E. Schafer, July 1967-

AEROSPACE MEDICAL CENTER

Major General Otis O. Benson Jr., October 1959-February 1961
Major General Theodore C. Bedwell Jr., November 1961-January 1966

AEROSPACE MEDICAL DIVISION, AIR FORCE SYSTEMS COMMAND

Major General Theodore C. Bedwell Jr., February 1961-November 1961
Brigadier General Thomas H. Crouch, January 1966-May 1966
Major General Charles H. Roadman, May 1966-

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